PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-217029
(43)Date of publication of application : 02.08.2002

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(51)Int.Cl. H01F 10/16
G11B 5/31
H01F 10/30

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(21)Application number : 2001-005906
(22)Date of filing : 15.01.2001

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(54) SOFT MAGNETIC FILM, METHOD OF MANUFACTURING THE SAME THIN FILM MAGNETIC HEAD USING THE SAME, AND METHOD OF MANUFACTURING THE THIN FILM MAGNETIC HEAD

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a soft magnetic film which has a saturation magnetic flux density Bs higher than that Bs of an NiFe alloy film by properly adjusting the compositional ratio of a CoFeα alloy film being used for the soft magnetic film and moreover which is excellent also in an erosion resistance, and to provide a thin film magnetic head using this soft magnetic film, a method of manufacturing the soft magnetic film, and a method of manufacturing the thin film magnetic head.
SOLUTION: A lower magnetic pole layer 19 and/or an upper magnetic pole layer 21 are/is formed of a CoXFeYαZ alloy film to satisfy the relation between the compositional ratio X of Co = higher than 8 mass % to lower than 48 mass %, the compositional ratio Y of Fe = higher than 50 mass % to lower than 90 mass % and the compositional ratio Z of an element α (Provided that the element α is one side or both of Ni and Cr) = higher than 2 mass % to lower than 20 mass % and the compositional ratios X+Y+Z=100 mass %. Hereby, the saturation magnetic flux density of the alloy film can be set in a density of 2.0 T or higher and a thin film magnetic head excellent in an increase in a recording density can be manufactured using this alloy film.

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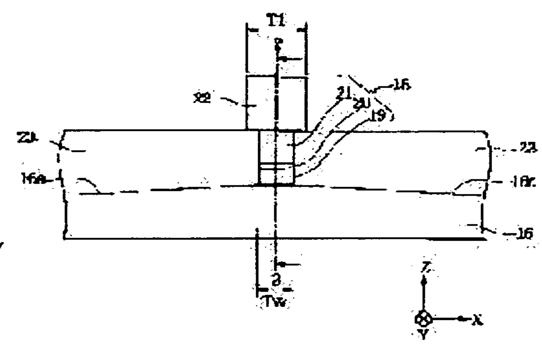

LEGAL STATUS

[Date of request for examination]	26.02.2003
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	

[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] composition ratio X+Y+Z=100 mass % An empirical formula is shown by CoXFeYalphaZ (Element alpha is one side or the both sides of nickel and Cr), the composition ratio X of Co is below 48 mass % above 8 mass %, the composition ratio Z of Element alpha is [the composition ratio Y of Fe is below 90 mass % above 50 mass %,] below 20 mass % above 2 mass %, and it is the soft-magnetism film characterized by filling an unrelated relation.
[Claim 2] composition ratio X+Y+Z=100 mass % It is 32 or less mass above 23 mass %, and the composition ratio Y of Fe is below 71 mass % above 58 mass %, the composition ratio Z of the aforementioned element alpha is below 20 mass % above 2 mass %, and the composition ratio X of Above Co is a soft-magnetism film according to claim 1 which fills an unrelated relation.
[Claim 3] composition ratio X+Y+Z=100 mass % It is below 28.3 mass % above 23.3 mass %, and the composition ratio Y of Above Fe is below 67.5 mass % above 63 mass %, the composition ratio Z of the aforementioned element alpha is below 13.6 mass % above 4.2 mass %, and the composition ratio X of Above Co is a soft-magnetism film according to claim 1 which fills an unrelated relation.
[Claim 4] composition ratio X+Y+Z=100 mass % The composition ratio Z of the composition ratio Y of the composition ratios X and Fe of Co and Element alpha is within the limits surrounded by three points, 25.5 = (X, Y, Z) (26.5 mass %, 64.6 mass %, 8.9 mass %), (mass %, 63 mass %, 11.5 mass %), and (23.3 mass %, 67.5 mass %, 9.2 mass %), and is a soft-magnetism film according to claim 1 which fills an unrelated relation.
[Claim 5] The saturation magnetic flux density of the aforementioned soft-magnetism film is a soft-magnetism film according to claim 1 to 4 which is more than 2.0T.
[Claim 6] The saturation magnetic flux density of the aforementioned soft-magnetism film is a soft-magnetism film according to claim 2 to 4 which is more than 2.15T.
[Claim 7] The aforementioned saturation magnetic flux density is a soft-magnetism film according to claim 3 or 4 which is 2.2 or more.
[Claim 8] It is the soft-magnetism film according to claim 1 to 7 whose Ra is 5nm or less in the center line average coarseness of the aforementioned soft-magnetism film.
[Claim 9] The soft-magnetism film according to claim 1 to 8 with which a passive state film is formed in the front face of the aforementioned soft-magnetism film.
[Claim 10] The soft-magnetism film according to claim 1 to 9 with which plating formation of the NiFe alloy film is carried out in piles on the aforementioned soft-magnetism film.
[Claim 11] The aforementioned soft-magnetism film is a soft-magnetism film according to claim 1 to 10 by which plating formation is carried out.
[Claim 12] It is the thin film magnetic head characterized by being formed with the soft-magnetism film with which one [at least] core layer was indicated by a claim 1 or either of 11 in the thin film magnetic head which has the lower core layer made from a magnetic material, the up cor layer formed through the magnetic gap on the aforementioned lower core layer, and the coil layer which gives a record magnetic field to both the core layer.
[Claim 13] The thin film magnetic head according to claim 12 in which the bosselation of the lower magnetic pole layer is carried out by the opposed face with a record medium on the

aforementioned lower core layer, and the aforementioned lower magnetic pole layer is formed with the aforementioned soft-magnetism film.
[Claim 14] The lower magnetic pole layer in which it has the following and the aforementioned magnetic pole section follows a lower core layer, the up magnetic pole layer which follows an up core layer, It consists of an aforementioned lower magnetic pole layer and a gap layer located between the aforementioned up magnetic pole layers. and or the aforementioned magnetic pole section It consists of gap layers located between the up magnetic pole layer which follows an up core layer, and the aforementioned up magnetic pole layer and a lower core layer. the aforementioned up magnetic pole layer and/or a lower magnetic pole layer The thin film magnetic head characterized by being formed with the soft-magnetism film indicated by a claim 1 or either of 11. A lower core layer and an up core layer. The magnetic pole section which is located between the aforementioned lower core layer and an up core layer and by which the width-of-face size of the direction of the width of recording track was regulated shorter than the aforementioned lower core layer and an up core layer.
[Claim 15] The up core layer which the aforementioned up magnetic pole layer is formed by the aforementioned soft-magnetism film, and is formed on the aforementioned up magnetic pole layer is the thin film magnetic head according to claim 14 by which plating formation is carried out by the NiFe alloy film.
[Claim 16] For the aforementioned core layer, the magnetic layer which the portion which adjoins a magnetic gap at least consists of the magnetic layer more than two-layer, or the aforementioned magnetic pole layer consists of the magnetic layer more than two-layer, and touches the aforementioned magnetic gap among the aforementioned magnetic layers is the thin film magnetic head according to claim 12 to 15 currently formed with the aforementioned soft-magnetism film.
[Claim 17] Other magnetic layers except touching the aforementioned magnetic-gap layer are the thin film magnetic head according to claim 16 by which plating formation is carried out with a NiFe alloy.
[Claim 18] By the electroplating method using the pulse current, the composition ratio X of Co is below 48 mass % above 8 mass %. the composition ratio Y of Fe -- more than 50 mass % -- below 90 mass % -- it is -- Element alpha (Element alpha -- nickel --) The manufacture method of the soft-magnetism film characterized by the composition ratio Z of one side of Cr or both sides carrying out plating formation of the CoXFeYalphaZ alloy film which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be, and with which a relation is filled above 2 mass %.
[Claim 19] Make Fe ion concentration / Co ion concentration under plating bath or more into 1.5, and Fe ion concentration / alpha ion concentration is made or less into four by two or more. The composition ratio X of Above Co is below 32 mass % above 23 mass %, and the composition ratio Y of Fe is below 71 mass % above 58 mass %. The manufacture method of a soft-magnetism film according to claim 18 that the composition ratio Z of Element alpha carries out plating formation of the CoXFeYalphaZ alloy film which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be and with which a relation is filled above 2 mass %.
[Claim 20] Make Fe ion concentration / Co ion concentration under plating bath or more into 1.5, and Fe ion concentration / alpha ion concentration is made or less into 3.4 by two or more. The composition ratio X of Co is below 28.3 mass % above 23.3 mass %. the composition ratio Y of Above Fe composition ratio X+Y+Z=100 mass % It is below 67.5 mass % above 63 mass %, the composition ratio Z of the aforementioned element alpha is below 13.6 mass % above 4.2 mass %, and it is the manufacture method of the soft-magnetism film according to claim 18 which carries out plating formation of the CoXFeYalphaZ alloy film which fills an unrelated relation.
[Claim 21] Make Fe ion concentration / Co ion concentration under plating bath or more into 1.7, and Fe ion concentration / alpha ion concentration is made or less into 3.4 by two or more. the composition ratio Z of the composition ratio Y of the composition ratios X and Fe of Co, and Element alpha (X --) Y and Z= (26.5 mass %, 64.6 mass %, 8.9 mass %) (25.5 mass % --) The manufacture method of the soft-magnetism film according to claim 18 which carries out plating formation of the CoXFeYNiZ alloy film which composition ratio X+Y+Z=100 mass % Comes to be

within the limits surrounded by three points, 23.3 63 mass %, 11.5 mass %, and (mass %, 67.5 mass %, 9.2 mass %), and which fills a relation.

[Claim 22] The manufacture method of the soft-magnetism film according to claim 18 or 21 which mixes a saccharin sodium during a plating bath.

[Claim 23] The manufacture method of the soft-magnetism film according to claim 18 to 22 which mixes the 2-butyne -1 and four diols during the aforementioned plating bath.

[Claim 24] The manufacture method of the soft-magnetism film according to claim 18 to 23 which mixes a 2-ethylhexyl sodium sulfate during the aforementioned plating bath.

[Claim 25] The manufacture method of the thin film magnetic head characterized by to carry out plating formation of one [at least] core layer in the manufacture method of the thin film magnetic head of having the aforementioned lower core layer, the up core layer which counters through a magnetic gap, and the coil layer which guides a record magnetic field to both the core layer, by the soft-magnetism film by the manufacture method indicated by a claim 18 or either of 24 at the lower core layer made from a magnetic material, and an opposed face with a record medium.

[Claim 26] The manufacture method of the thin film magnetic head according to claim 25 which carries out the bosselation of the lower magnetic pole layer by the opposed face with a record medium on the aforementioned lower core layer, and carries out plating formation of the aforementioned lower magnetic pole layer by the aforementioned soft-magnetism film.

[Claim 27] The lower magnetic pole layer which is equipped with the following and follows a lower core layer in the aforementioned magnetic pole section, the up magnetic pole layer which follows an up core layer, And it forms in the aforementioned lower magnetic pole layer and the gap layer located between the aforementioned up magnetic pole layers. Or the aforementioned magnetic pole section is formed in the gap layer located between the up magnetic pole layer which follows an up core layer, and the aforementioned up magnetic pole layer and a lower core layer. The manufacture method of the thin film magnetic head characterized by carrying out plating formation of the aforementioned up magnetic pole layer and/or the lower magnetic pole layer by the soft-magnetism film by the manufacture method indicated by a claim 18 or either of 24 at this time. A lower core layer and an up core layer. The magnetic pole section which is located between the aforementioned lower core layer and an up core layer and by which the width-of-face size of the direction of the width of recording track was regulated shorter than the aforementioned lower core layer and an up core layer.

[Claim 28] The manufacture method of the thin film magnetic head according to claim 27 which carries out plating formation of the aforementioned up magnetic pole layer by the aforementioned soft-magnetism film, and carries out plating formation of the up core layer by the NiFe alloy film by the electroplating method on the aforementioned up magnetic pole layer.

[Claim 29] The manufacture method of the thin film magnetic head according to claim 25 to 28 which carries out plating formation of the magnetic layer which forms the aforementioned core layer by the magnetic layer more than two-layer in the portion which adjoins a magnetic gap at least, or forms the aforementioned magnetic pole layer by the magnetic layer more than two-layer, and touches the aforementioned magnetic gap among the aforementioned magnetic layers at this time with the aforementioned soft-magnetism film.

[Claim 30] The manufacture method of the thin film magnetic head according to claim 29 which carries out plating formation of other magnetic layers except touching the aforementioned magnetic-gap layer with a NiFe alloy by the electroplating method.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] While this invention can make larger than Bs of a NiFe alloy saturation magnetic flux density Bs of the CoFealpha (Element alpha is nickel) alloy used as core material of the thin film magnetic head, it relates to the manufacture method of the aforementioned soft-magnetism film, and the manufacture method of the aforementioned thin film magnetic head at the thin film magnetic head and the row using the soft-magnetism film excellent in corrosion resistance, and this soft-magnetism film.
[0002]
[Description of the Prior Art] For example, it is necessary to use the magnetic material which has the high saturation magnetic flux density Bs with a raise in future recording density especially for the core layer of the thin film magnetic head, to centralize magnetic flux near the gap of the aforementioned core layer, and to raise recording density.
[0003] The NiFe alloy is often used for the aforementioned magnetic material from the former. Plating formation is carried out by the electroplating method which used the direct current, and the aforementioned NiFe alloy can obtain the about [1.8T] saturation magnetic flux density Bs.
[0004]
[Problem(s) to be Solved by the Invention] In order to raise further the saturation magnetic flux density Bs of the aforementioned NiFe alloy, it replaces with the electroplating method using the direct current, and the electroplating method by the pulse current is used.
[0005] Although this was enabled to raise Bs of the aforementioned NiFe alloy, saturation magnetic flux density Bs was not able to be carried out more than 2.0T. And ****** of a film surface became severe and there was a problem that it was eaten away by various solvents with which the aforementioned NiFe alloy is used in process in which the thin film magnetic head is manufactured.
[0006] Thus, with a NiFe alloy, while it had the high saturation magnetic flux density Bs, the soft-magnetism film excellent in corrosion resistance was not able to be formed.
[0007] Moreover, there is a CoFe alloy film as soft magnetic materials often in addition to a NiFe alloy used. The aforementioned CoFe alloy film was adjusting the composition ratio of Fe proper, and while the saturation magnetic flux density Bs higher than a NiFe alloy film was obtained, the following troubles generated it.
[0008] Although a NiFe alloy may be piled up on the aforementioned CoFe alloy depending on the composition of the thin film magnetic head or other magnetic cells, when carrying out plating formation of the NiFe alloy film by the electroplating method on the aforementioned CoFe alloy film, the CoFe alloy film ionized and the problem of having melted [begin] and corroding occurred.
[0009] This is because the big potential difference (normal electrode potential difference) occurs between the aforementioned CoFe alloy film and a NiFe alloy film, and is considered that the so-called cell effect arises by this potential difference, and it begun to melt. Therefore, when plating formation of the soft-magnetism film and NiFe alloy film which have high saturation magnetic flux density especially was carried out in piles, a CoFe alloy was not able to be used for the

aforementioned soft-magnetism film.
[0010] Moreover, it is one of the soft-magnetism films with which a CoFeNi film is also often used in addition to a NiFe alloy film or a CoFe alloy film. For example, four CoFeNi alloy films and soft magnetic characteristics from which a composition ratio differs in Table 2 are indicated by JP,10-199726,A.
[0011] However, in the composition ratio of the CoFeNi alloy film in this official report, all, saturation magnetic flux density Bs is less than 2.0T, and cannot obtain the big saturation magnetic flux density Bs effectively compared with a NiFe alloy film.
[0012] Then, this invention aims at providing with the manufacture method of the aforementioned soft-magnetism film, and the manufacture method of the thin film magnetic head the thin film magnetic head using the soft-magnetism film which it was and was rationalizing the composition ratio of a CoFealpha alloy, was more expensive than Bs of a NiFe alloy and was moreover excellent also in corrosion resistance in saturation magnetic flux density Bs and this soft-magnetism film for solving the above-mentioned conventional technical problem, and a row.
[0013] Moreover, this invention can prevent that the aforementioned CoFealpha alloy begins to melt into a CoFealpha alloy even if it carries out plating formation of the NiFe alloy in piles, and aims at providing with the manufacture method of the aforementioned soft-magnetism film, and the manufacture method of the thin film magnetic head the thin film magnetic head using the soft-magnetism film which can maintain the high saturation magnetic flux density Bs, and this soft-magnetism film, and a row.
[0014]
[Means for Solving the Problem] As for the soft-magnetism film in this invention, an empirical formula is shown by CoXFeYalphaZ (Element alpha is one side or the both sides of nickel and Cr). the composition ratio X of Co It is below 48 mass % above 8 mass %, and the composition ratio Y of Fe is below 90 mass % above 50 mass %, and the composition ratio Z of Element alpha is below 20 mass % above 2 mass %, and it is characterized by filling an unrelated relation composition ratio X+Y+Z=100 mass 5.
[0015] Saturation magnetic flux density Bs can be carried out to it being the CoFealpha alloy which has this composition more than 2.0T. Thus, in this invention, the saturation magnetic flux density Bs higher than a NiFe alloy can be obtained.
[0016] And big and rough-ization of the diameter of crystal grain is suppressed, a crystal is formed precisely, and ****** of a film surface can be made small. Therefore, in this invention, while the high saturation magnetic flux density Bs beyond 2.0T can be obtained, the soft-magnetism film excellent in corrosion resistance can be manufactured.
[0017] Moreover, it is desirable that the composition ratio X of Above Co is below 32 mass % above 23 mass %, the composition ratio Y of Fe is below 71 mass % above 58 mass %, and the composition ratio Z of Element alpha fills with this invention the relation it composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be / relation / above 2 mass %.
[0018] Saturation magnetic flux density Bs can be carried out to it being this composition within the limits more than 2.15T. And Ra can be set to 5nm or less in the center line average coarseness of a film surface, and it is possible to raise corrosion resistance more effectively.
[0019] Moreover, it is more desirable that the composition ratio X of Above Co is below 28.3 mass % above 23.3 mass %, the composition ratio Y of Above Fe is below 67.5 mass % above 63 mass %, and the composition ratio Z of the aforementioned element alpha fills with this invention the relation it composition ratio X+Y+Z=100 mass % Comes [% / 13.6 mass / below] to be / relation / above 4.2 mass %. Thereby, saturation magnetic flux density Bs is made more than 2.2T. And Ra can be set to 5nm or less in the center line average coarseness of a film surface, and it is possible to raise corrosion resistance more effectively.
[0020] moreover -- this invention -- the composition ratio Z of the composition ratio Y of the composition ratios X and Fe of Co, and Element alpha (X --) Y and Z= (26.5 mass %, 64.6 mass %, 8.9 mass %) (25.5 mass % --) It is most desirable to fill the relation which composition ratio X+Y+Z=100 mass % Comes to be within the limits surrounded by three points, 23.3 63 mass %, 11.5 mass %, and (mass %, 67.5 mass %, 9.2 mass %). Thereby, saturation magnetic flux density can be made larger than 2.2T. It is checked in the experiment which it mentions later that

especially the aforementioned saturation magnetic flux density is made to 2.25T at the maximum. And Ra can be set to 5nm or less in the center line average coarseness of a film surface, and it is possible to raise corrosion resistance more effectively.
[0021] Moreover, it is desirable that a passive state film is formed in the front face of the aforementioned soft-magnetism film in this invention. The aforementioned passive state film is a precise oxide film, and the aforementioned passive state film is formed by nickel and Cr being contained in a soft-magnetism film.
[0022] Thus, even when the passive state film was formed in the front face of a soft-magnetism film and plating formation of the NiFe alloy film is carried out in piles on the aforementioned soft-magnetism film, it is possible to prevent for the aforementioned CoFealpha alloy to ionize and to begin to melt.
[0023] Therefore, in this invention, even when plating formation of the NiFe alloy film is carried out on the aforementioned CoFealpha alloy film, the high saturation magnetic flux density Bs and high corrosion resistance of the aforementioned CoFealpha alloy can be maintained appropriately.
[0024] Moreover, as for the aforementioned soft-magnetism film, in this invention, it is desirable that plating formation is carried out. It becomes possible forming by thick thickness rather than being able to form the aforementioned soft-magnetism film by arbitrary thickness and being formed by the spatter of this.
[0025] Moreover, in the thin film magnetic head in which this invention has the lower core layer made from a magnetic material, the up core layer formed through the magnetic gap on the aforementioned lower core layer, and the coil layer which gives a record magnetic field to both the core layer, one [at least] core layer is characterized by being formed with the soft-magnetism film indicated above.
[0026] Moreover, it is desirable that upheaval formation of the lower magnetic pole layer is carried out by the opposed face with a record medium on the aforementioned lower core layer, and the aforementioned lower magnetic pole layer is formed with the aforementioned soft-magnetism film in this invention.
[0027] Or this invention is located between a lower core layer and an up core layer, and the aforementioned lower core layer and an up core layer, and has the magnetic pole section by which the width-of-face size of the direction of the width of recording track was regulated shorter than the aforementioned lower core layer and an up core layer. The lower magnetic pole layer in which the aforementioned magnetic pole section follows a lower core layer, the up magnetic pole layer which follows an up core layer, It consists of an aforementioned lower magnetic pole layer and a gap layer located between the aforementioned up magnetic pole layers. and or the aforementioned magnetic pole section It consists of gap layers located between the up magnetic pole layer which follows an up core layer, and the aforementioned up magnetic pole layer and a lower core layer, and the aforementioned up magnetic pole layer and/or a lower magnetic pole layer are characterized by being formed with the soft-magnetism film indicated above.
[0028] In addition, as for the up core layer which the aforementioned up magnetic pole layer is formed by the aforementioned soft-magnetism film, and is formed on the aforementioned up magnetic pole layer, it is desirable at this time that plating formation is carried out by the NiFe alloy film.
[0029] Moreover, it is desirable that the magnetic layer which the portion in which the aforementioned core layer adjoins a magnetic gap at least at this invention consists of the magnetic layer more than two-layer, or the aforementioned magnetic pole layer consists of the magnetic layer more than two-layer, and touches the aforementioned magnetic gap among the aforementioned magnetic layers is formed with the aforementioned soft-magnetism film.
[0030] Moreover, as for other magnetic layers except touching the aforementioned magnetic-gap layer, it is desirable that plating formation is carried out with a NiFe alloy.
[0031] As described above, the CoFealpha alloy as a soft-magnetism film in this invention has saturation magnetic flux density Bs as high as more than 2.0T, and its ****** is also small. It is possible to manufacture the thin film magnetic head which could attain centralization of the

magnetic flux near the gap, and could be made to promote high recording density-ization, and was excellent in corrosion resistance to use such a soft-magnetism film as core material of the thin film magnetic head.
[0032] The manufacture method of the soft-magnetism film in this invention by moreover, the electroplating method which used the pulse current The composition ratio X of Co is below 48 mass % above 8 mass %, and the composition ratio Y of Fe is below 90 mass % above 50 mass %. composition ratio X+Y+Z=100 mass % The composition ratio Z of Element alpha (Element alpha is one side or the both sides of nickel and Cr) is below 20 mass % above 2 mass %, and it is characterized by carrying out plating formation of the CoXFeYalphaZ alloy film which fills an unrelated relation.
[0033] The amount of Fe(s) has big influence on saturation magnetic flux density Bs. Bs will become small if there are few amounts of Fe(s). The amount of Fe(s) is 30 mass % at the maximum, and the CoFeNi alloy mentioned to Table 2 of JP,10-199726,A is considered that it is one of the causes by which saturation magnetic flux density Bs becomes smaller than 2.0T that there are few amounts of Fe(s) in this way.
[0034] On the other hand, it was difficult like before to increase the amount of Fe(s) by the method of carrying out plating formation by the electroplating method using the direct current, for example, the increase of the amount of Fe(s) or the CoFeNi alloy which there is a limitation also in this and has the saturation magnetic flux density Bs beyond 2.0T although it tried when met in a film were not able to be obtained by raising Fe ion concentration under plating bath.
[0035] Then, in this invention, plating formation of the CoFealpha alloy is carried out by the electroplating method which used the pulse current. By the electroplating method using the pulse current, ON/OFF of a current controlling element is repeated, for example, and time to pass current at the time of plating formation and blank time not to pass current are prepared. Thus, it is possible to carry out plating formation little by little, to compare a CoFealpha alloy film with the electroplating method using the direct current by preparing time not passing current, and to ease the bias of a distribution of the current density at the time of plating formation. According to the electroplating method by the pulse current, adjustment of Fe content contained in a soft-magnetism film compared with the electroplating method by the direct current becomes easy, and can incorporate many aforementioned Fe contents in a film.
[0036] According to this invention, the composition ratio Y of Fe can be made below into 90 mass % above 50 mass %. The below-mentioned experiment shows that saturation magnetic flux density Bs is made more than 2.0T by this. Although the remainder serves as Co and a composition ratio of Element alpha, if Element alpha is put in too much, the below-mentioned experiment shows that saturation magnetic flux density Bs falls rather than 2.0T. In this invention, it became possible to carry out plating manufacture of the CoFealpha alloy which saturation magnetic flux density Bs is more than 2.0T, and was excellent also in corrosion resistance making the composition ratio X of Co below into 48 mass % above 8 mass %, and making the composition ratio Z of Element alpha below into 20 mass % above 2 mass %.
[0037] Moreover, in this invention, Fe ion concentration / Co ion concentration under plating bath are made or more into 1.5. Fe ion concentration / alpha ion concentration is made or less into four by two or more, and the composition ratio X of Above Co is below 32 mass % above 23 mass %. The composition ratio Y of Fe is below 71 mass % above 58 mass %, and it is desirable that the composition ratio Z of Element alpha carries out plating formation of the CoXFeYalphaZ alloy film which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be and with which a relation is filled above 2 mass %.
[0038] As shown in the experiment mentioned later, with the CoFealpha alloy formed by the above-mentioned ion concentration ratio, it becomes possible to carry out plating manufacture of the soft-magnetism film as for which could do saturation magnetic flux density Bs more than 2.15T, and the center line average coarseness of a film surface was made to 5nm or less and which was effectively excellent in high saturation magnetic flux density Bs and high corrosion resistance.
[0039] Moreover, in this invention, Fe ion concentration / Co ion concentration under plating bath are made or more into 1.5. Fe ion concentration / alpha ion concentration is made or less

into 3.4 by two or more, and the composition ratio X of Co is below 28.3 mass % above 23.3 mass %. the composition ratio Y of Above Fe It is below 67.5 mass % above 63 mass %, and, as for the composition ratio Z of the aforementioned element alpha, it is more desirable to carry out plating formation of the CoXFeYalphaZ alloy film which composition ratio X+Y+Z=100 mass % Comes [% / 13.6 mass / below] to be and which fills a relation above 4.2 mass %. As shown in the experiment mentioned later, with the CoFealpha alloy formed by the above-mentioned ion concentration ratio, saturation magnetic flux density Bs is made more than 2.2T.

[0040] Moreover, in this invention, Fe ion concentration / Co ion concentration under plating bath are made or more into 1.7. Fe ion concentration / alpha ion concentration is made or less into 3.4 by two or more. The composition ratio X of Co the composition ratio Y of Fe, and the composition ratio of ****** alpha -- Z= (X, Y, Z) (26.5 mass % --) 64.6 mass % and 8.9 mass % (25.5 mass % and 63 mass % --) It is most desirable to carry out plating formation of the CoXFeYalphaZ alloy film which composition ratio X+Y+Z=100 mass % Comes to be within the limits surrounded by three points, 23.3 11.5 mass %, and (mass %, 67.5 mass %, 9.2 mass %), and which fills a relation. As shown in the experiment mentioned later, with the CoFealpha alloy formed by the above-mentioned ion concentration ratio, saturation magnetic flux density Bs can be made larger than 2.2T.

[0041] Moreover, it is desirable to mix a saccharin sodium during the plating bath of a CoFealpha alloy in this invention. It is possible to reduce the membrane stress of a CoFealpha alloy by the saccharin sodium (C6H4CONNaSO2) having a role of a stress relaxation agent, therefore mixing the aforementioned saccharin sodium.

[0042] Moreover, it is desirable to mix the 2-butyne -1 and four diols during the aforementioned plating bath in this invention. Big and rough-ization of the diameter of crystal grain of a CoFealpha alloy by which plating formation was carried out is suppressed, the aforementioned diameter of crystal grain is small, an opening stops being generated in a bird clapper for it easily between crystals, and ****** of a film surface is suppressed by this. It also becomes possible to make coercive force Hc small by the ability of ****** to be suppressed.

[0043] Moreover, it is desirable to mix a 2-ethylhexyl sodium sulfate during the aforementioned plating bath in this invention. The hydrogen produced during a plating bath by this is removed by the 2-ethylhexyl sodium sulfate which is a surfactant, and can suppress ****** by the aforementioned hydrogen adhering to a plating film.

[0044] Moreover, although it may replace with the aforementioned 2-ethylhexyl sodium sulfate and a sodium lauryl sulfate may be used, it enables it for there to be little foaming when the direction which used the 2-ethylhexyl sodium sulfate mixes during a plating bath, therefore to be able to mix many aforementioned 2-ethylhexyl sodium sulfates during a plating bath, and to remove the aforementioned hydrogen more appropriately.

[0045] Moreover, this invention is characterized by carrying out plating formation of one [at least] core layer by the soft-magnetism film by the manufacture method indicated above at the lower core layer made from a magnetic material, and an opposed face with a record medium in the manufacture method of the thin film magnetic head of having the aforementioned lower core layer, the up core layer which counters through a magnetic gap, and the coil layer which guides a record magnetic field to both the core layer.

[0046] Moreover, it is desirable to carry out the bosselation of the lower magnetic pole layer by th opposed face with a record medium on the aforementioned lower core layer, and to carry out plating formation of the aforementioned lower magnetic pole layer by the aforementioned soft-magnetism film in this invention.

[0047] Moreover, this invention is located between a lower core layer and an up core layer, and the aforementioned lower core layer and an up core layer, and has the magnetic pole section by which the width-of-face size of the direction of the width of recording track was regulated shorter than the aforementioned lower core layer and an up core layer. The lower magnetic pole layer which follows a lower core layer in the aforementioned magnetic pole section, the up magnetic pole layer which follows an up core layer, And it forms in the aforementioned lower magnetic pole layer and the gap layer located between the aforementioned up magnetic pole layers. Or the aforementioned magnetic pole section is formed in the gap layer located between

the up magnetic pole layer which follows an up core layer, and the aforementioned up magnetic pole layer and a lower core layer. It is characterized by carrying out plating formation of the aforementioned up magnetic pole layer and/or the lower magnetic pole layer by the soft-magnetism film by the manufacture method indicated above at this time.
[0048] Moreover, it is desirable to carry out plating formation of the aforementioned up magnetic pole layer by the aforementioned soft-magnetism film, and to carry out plating formation of the up core layer by the NiFe alloy film by the electroplating method on the aforementioned up magnetic pole layer this invention.
[0049] Moreover, it is desirable to carry out plating formation of the magnetic layer which forms the aforementioned core layer by the magnetic layer more than two-layer in the portion which adjoins a magnetic gap at least, or forms the aforementioned magnetic pole layer by the magnetic layer more than two-layer, and touches the aforementioned magnetic gap among the aforementioned magnetic layers in this invention at this time with the aforementioned soft-magnetism film.
[0050] Moreover, it is desirable to carry out plating formation of other magnetic layers except touching the aforementioned magnetic-gap layer with a NiFe alloy by the electroplating method this invention.
[0051] As described above, by carrying out plating formation by the electroplating method using the pulse current, the CoFealpha alloy as a soft-magnetism film in this invention The composition ratio X of Co is below 48 mass % above 8 mass %, the composition ratio Y of Fe is below 90 mass % above 50 mass %, and it is Element alpha (however, Element alpha). The composition ratio Z of one side of nickel and Cr or both sides is able to carry out plating formation of the CoXFeYalphaZ alloy which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be and with which a relation is filled above 2 mass %.
[0052] And it is possible to manufacture the thin film magnetic head which saturation magnetic flux density Bs could attain high recording density-ization highly, and was excellent also in corrosion resistance to use such a soft-magnetism film as core material of the thin film magnetic head with the sufficient yield.
[0053]
[Embodiments of the Invention] It is drawing of longitudinal section which cut the thin film magnetic head which shows drawing 1 in the partial front view of the thin film magnetic head of the 1st operation gestalt of this invention, and shows drawing 2 to drawing 1 from two to 2 line, and was seen from the arrow.
[0054] The thin film magnetic head in this invention is formed in trailing side edge side 11a of the slider 11 of the ceramic material which constitutes a surfacing formula head, and is MR / inductive compound-die thin film magnetic head (only henceforth the thin film magnetic head) to which the laminating of MR head h1 and the inductive head h2 for writing was carried out.
[0055] MR head h1 detects the leak magnetic field from record media, such as a hard disk, using the magnetoresistance effect, and reads a record signal.
[0056] As shown in drawing 2 , the lower shield layer 13 made from a magnetic material which consists of NiFe etc. through 2Oaluminum3 film 12 is formed on trailing side edge side 11a of the aforementioned slider 11, and the lower gap layer 14 made from an insulating material is further formed on it.
[0057] On the aforementioned lower gap layer 14, the magnetoresistance-effect elements 10, such as an anisotropy magnetoresistance-effect (AMR) element, a huge magnetoresistance-effect (GMR) element, or a tunneled type magnetoresistance-effect (TMR) element, are formed towards the height direction (the direction of illustration Y) from an opposed face with a record medium, and the up gap layer 15 made from an insulating material is further formed on the aforementioned magnetoresistance-effect element 10 and the lower gap layer 14. The up shield layer 16 furthermore formed by magnetic materials, such as NiFe, on the aforementioned up gap layer 15 is formed. MR head h1 consists of cascade screens from the aforementioned lower shield layer 13 to the up shield layer 16.
[0058] Next, with the operation gestalt shown in drawing 1 and 2, the aforementioned up shield layer 16 is made to serve a double purpose also as a lower core layer of an inductive head h2,

Gd arrangement layer 17 is formed on the aforementioned lower core layer 16, and a gap depth (Gd) is regulated by the linear dimension from an opposed face with a record medium to the point of the aforementioned Gd arrangement layer 17. The aforementioned Gd arrangement layer 17 is formed for example, by the organic insulating material.
[0059] Moreover, upper surface 16a of the aforementioned lower core layer 16 is formed in the inclined plane which inclines in the direction of an inferior surface of tongue as are shown in drawing 1 and it is separated from the end face of the magnetic pole section 18 in the direction of the width of recording track (the direction of illustration X), and it is possible for this to suppress generating of side fringing.
[0060] Moreover, as shown in drawing 2 , it applies on the aforementioned Gd arrangement layer 17 from an opposed face with a record medium, and the magnetic pole section 18 is formed.
[0061] As for the aforementioned magnetic pole section 18, the laminating of the lower shell lower magnetic pole layer 19, the nonmagnetic gap layer 20, and the up magnetic pole layer 21 is carried out.
[0062] Direct plating formation of the aforementioned lower magnetic pole layer 19 is carried out on the lower core layer 16. Moreover, as for the gap layer 20 formed on the aforementioned lower magnetic pole layer 19, it is desirable to be formed with the non-magnetic metal material in which plating formation is possible. Specifically, it is desirable to be chosen from one sort or two sorts or more in NiP, NiPd, NiW, NiMo, and Au, Pt, Rh, Pd, Ru and Cr.
[0063] In addition, NiP is used for the aforementioned gap layer 20 as a concrete operation gestalt in this invention. It is because the aforementioned gap layer 20 changes into a nonmagnetic state appropriately by forming the aforementioned gap layer 20 by NiP.
[0064] The up magnetic pole layer 21 furthermore formed on the aforementioned gap layer 20 is magnetically connected with the up core layer 22 formed on it.
[0065] If the gap layer 20 is formed as mentioned above with the non-magnetic metal material in which plating formation is possible, it is possible to carry out continuation plating formation of the lower magnetic pole layer 19, the gap layer 20, and the up magnetic pole layer 21.
[0066] In addition, the aforementioned magnetic pole section 18 may consist of two-layer [of the gap layer 20 and the up magnetic pole layer 21].
[0067] As shown in drawing 1 , the width-of-face size [in / the direction of the width of recording track (the direction of illustration X) / in the aforementioned magnetic pole section 18] is formed by the width of recording track Tw.
[0068] As shown in drawing 1 and drawing 2 , the insulating layer 23 is formed the both sides and behind [height direction] (the direction of illustration Y) the aforementioned magnetic pole section 18. [of the direction of the width of recording track (the direction of illustration X)] Let the upper surface of the aforementioned insulating layer 23 be the same flat surface as the upper surface of the aforementioned magnetic pole section 18.
[0069] As shown in drawing 2 , on the aforementioned insulating layer 23, pattern formation of the coil layer 24 is carried out spirally. Moreover, the aforementioned coil layer 24 top is covered by the insulating layer 25 made from an organic insulation.
[0070] As shown in drawing 2 , it applies on an insulating layer 25 from on the magnetic pole section 18, and pattern formation of the up core layer 22 is carried out for example, by frame plating. As shown in drawing 1 , a width-of-face size [in / the direction of the width of recording track in an opposed face with a record medium / in point 22a of the aforementioned up core layer 22] is formed by T1, and this width-of-face size T1 is formed more greatly than the width of recording track Tw.
[0071] Moreover, as shown in drawing 2 , the direct file of the end face section 22b of the aforementioned up core layer 22 is carried out on the connection layer 26 made from the magnetic material formed on the lower core layer 16 (back gap layer).
[0072] In this invention, the aforementioned up magnetic pole layer 21 and/or the lower magnetic pole layer 19 are formed by the soft-magnetism film which has the following composition ratios.
[0073] An empirical formula is shown by CoXFeYalphaZ (however, the element alpha one side or the both sides of nickel and Cr), the composition ratio X of Co is below 48 mass % above 8 mass %, the composition ratio Y of Fe is below 90 mass % above 50 mass %, and the composition ratio

Z of Element alpha fills the relation which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be above 2 mass %.
[0074] Saturation magnetic flux density Bs can be made so large that there are many amounts of Fe(s). However, if the amount of Fe(s) increases too much, while ****** of a film surface will become severe by big and rough-ization of the diameter of crystal grain and corrosion resistance will fall, saturation magnetic flux density Bs will also fall.
[0075] By this invention, saturation magnetic flux density can be carried out more than 2.0T by making the amount of Fe(s) below into 90 mass % as mentioned above above 50 mass %.
[0076] Although the remaining composition ratios except the amount of Fe(s) turn into a composition ratio of Co, and a composition ratio of Element alpha, since the saturation magnetic flux density Bs higher than the permalloy which is adding Co and consists only of nickel and Fe is obtained, optimum dose addition of the Co needs to be carried out. On the other hand, if Element alpha is added, since saturation magnetic flux density Bs will fall rather than the magnetic material which consists only of Co and Fe, the amount of Element alpha needs to be added by the grade to which saturation magnetic flux density Bs does not become smaller than 2.0T. When Element alpha was made [more] by experiment than 20 mass, saturation magnetic flux density Bs is smaller than 2.0T, and the bird clapper was found.
[0077] Based on the above-mentioned viewpoint, by this invention, the composition ratio X of Co was made below into 48 mass % above 8 mass %, the composition ratio Y of Fe was made below into 90 mass % above 50 mass %, and the composition ratio Z of Element alpha was made below into 20 mass % above 2 mass %. Thereby, saturation magnetic flux density Bs can be carried out more than 2.0T. Moreover, in this invention, it is stabilized and high saturation magnetic flux density can be obtained.
[0078] Moreover, ****** of a film surface can be lessened by a crystal being formed precisely, corrosion resistance can be raised, and coercive force Hc can be further made small. It is possible to specifically make the aforementioned coercive force below into 1580 (A/m).
[0079] Moreover, the specific resistance more than 15 (muomega and cm) can be obtained as a CoFealpha alloy is above-mentioned composition within the limits. Moreover, membrane stress can be set to 400 or less MPas. Furthermore about an anisotropy field Hk, the anisotropy field Hk of the same grade as the NiFe alloy currently generally used as soft magnetic materials from the former can be obtained.
[0080] Moreover, it is desirable that the composition ratio X of Above Co is below 32 mass % above 23 mass %, the composition ratio Y of Fe is below 71 mass % above 58 mass %, and the composition ratio Z of Element alpha fills with this invention the relation it composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be / relation / above 2 mass %.
[0081] Saturation magnetic flux density Bs can be raised further by this, and the saturation magnetic flux density Bs beyond 2.15T can specifically be obtained. Moreover, Ra can be certainly set to 5nm or less in the center line average coarseness of a film surface. Therefore, it is possible to manufacture the soft-magnetism film which has the high saturation magnetic flux density Bs still more effectively, and was excellent in corrosion resistance.
[0082] Moreover, it is more desirable that the composition ratio X of Above Co is below 28.3 mass % above 23.3 mass %, the composition ratio Y of Above Fe is below 67.5 mass % above 63 mass %, and the composition ratio Z of the aforementioned element alpha fills with this invention the relation it composition ratio X+Y+Z=100 mass % Comes [% / 13.6 mass / below] to be / relation / above 4.2 mass %. Thereby, saturation magnetic flux density is made more than 2.2T. Moreover, Ra can be certainly set to 5nm or less in the center line average coarseness of a film surface.
[0083] moreover -- this invention -- the composition ratio Z of the composition ratio Y of the composition ratios X and Fe of Co, and Element alpha (X --) Y and Z= (26.5 mass %, 64.6 mass %, 8.9 mass %) (25.5 mass % --) It is most desirable to fill the relation which composition ratio X+Y+Z=100 mass % Comes to be within the limits surrounded by three points, 23.3 63 mass %, 11.5 mass %, and (mass %, 67.5 mass %, 9.2 mass %). Thereby, saturation magnetic flux density can be made larger than 2.2T. Moreover, Ra can be certainly set to 5nm or less in the center line average coarseness of a film surface. For example, if 24.6 mass % and the composition ratio of

Element alpha are made [the composition ratio of Fe] into 9.3 mass % for 66.1 mass % and the composition ratio of Co, it is checked that saturation magnetic flux density is made to 2.25T.
[0084] In addition, it is desirable to choose nickel as the aforementioned element alpha. That is, it is desirable to form the up magnetic pole layer 21 and/or the lower magnetic pole layer 19 with a CoFeNi alloy. By being above-mentioned composition within the limits, and forming the aforementioned CoFeNi alloy, saturation magnetic flux density Bs is certainly made more than 2.0T. Moreover, it is possible to make membrane stress small especially by addition of nickel.
[0085] As mentioned above, since it is possible for saturation magnetic flux density Bs to acquire more than 2.0T and a high value as for the CoFealpha alloy described above in this invention, by using it for the up magnetic pole layer 21 and/or the lower magnetic pole layer 19, magnetic flux is centralized near the gap of the aforementioned magnetic pole layer, and it can raise recording density. Therefore, the thin film magnetic head which can respond to future high recording density-ization can be manufactured. And the CoFealpha alloy which is above-mentioned composition within the limits, and was formed has little ****** of a film surface, and is excellent in corrosion resistance, and is the low coercive force Hc.
[0086] They are the partial front view showing the structure of the thin film magnetic head of the 2nd operation form [in / this invention / in drawing 3], and drawing of longitudinal section which drawing 4 cut the thin film magnetic head from 4-4 line shown in drawing 3 , and was seen from the arrow.
[0087] With this operation gestalt, the structure of MR head h1 is the same as drawing 1 and drawing 2 . As shown in drawing 3 , the insulating layer 31 is formed on the lower core layer 16. Width-of-recording-track formation slot 31a formed in the height direction (direction of illustration Y) back by predetermined linear dimension from the opposed face with a record medium is formed in the aforementioned insulating layer 31. The aforementioned width-of-recording-track formation slot 31a is formed by the width of recording track Tw in the opposed face with a record medium (refer to drawing 3).
[0088] The magnetic pole section 30 to which the laminating of the lower shell lower magnetic pole layer 32, the nonmagnetic gap layer 33, and the up magnetic pole layer 34 was carried out is formed in aforementioned width-of-recording-track formation slot 31a.
[0089] Direct plating formation of the aforementioned lower magnetic pole layer 32 is carried out on the lower core layer 16. Moreover, as for the gap layer 33 formed on the aforementioned lower magnetic pole layer 32, it is desirable to be formed with the non-magnetic metal material in which plating formation is possible. Specifically, it is desirable to be chosen from one sort or two sorts or more in NiP, NiPd, NiW, NiMo, and Au, Pt, Rh, Pd, Ru and Cr.
[0090] In addition, NiP is used for the aforementioned gap layer 33 as a concrete operation gestalt in this invention. It is because the aforementioned gap layer 33 changes into a nonmagnetic state appropriately by forming the aforementioned gap layer 33 by NiP.
[0091] In addition, the aforementioned magnetic pole section 30 may consist of two-layer [of the gap layer 33 and the up magnetic pole layer 34].
[0092] On the aforementioned gap layer 33, it applies on an insulating layer 31 from the position which separated only the gap depth (Gd) from the opposed face with a record medium, and Gd arrangement layer 37 is formed.
[0093] The up magnetic pole layer 34 furthermore formed on the aforementioned gap layer 33 is magnetically connected with the up core layer 40 formed on it.
[0094] If the gap layer 33 is formed as mentioned above with the non-magnetic metal material in which plating formation is possible, it is possible to carry out continuation plating formation of the lower magnetic pole layer 32, the gap layer 33, and the up magnetic pole layer 34.
[0095] As shown in drawing 4 , on the aforementioned insulating layer 31, pattern formation of the coil layer 38 is carried out spirally. The aforementioned coil layer 38 is covered by the insulating layer 39 formed by the organic insulating material etc.
[0096] As shown in drawing 3 , the inclined planes 31c and 31c where a width-of-face size spreads gradually according to the direction which is missing from upper surface 31b of the aforementioned insulating layer 31 from the upper surface of the aforementioned up magnetic pole layer 34, and separates from the lower core layer 16 are formed in the both-sides end face

in the direction of the width of recording track of width-of-recording-track regulation slot 31a (the direction of illustration X).
[0097] And as shown in drawing 3 , point 40a of the up core layer 40 is formed in the direction which applies on aforementioned inclined plane 31c and 31c from the up magnetic pole layer 34 aforementioned upper surface, and separates from the lower core layer 16.
[0098] As shown in drawing 4 , it is formed on an insulating layer 39, up core applying [aforementioned / 40] it in the height direction (the direction of illustration Y) from an opposed face with a record medium, and end face section 40b of the aforementioned up core layer 40 is directly formed on the lower core layer 16.
[0099] With the 2nd operation gestalt shown in drawing 3 and drawing 4 , the lower magnetic pole layer 32 and/or the up magnetic pole layer 34 The composition ratio X of Co is below 48 mass % above 8 mass %, the composition ratio Y of Fe is below 90 mass % above 50 mass %, and it is Element alpha (however, Element alpha). The composition ratio Z of one side of nickel and Cr or both sides is formed by CoXFeYalphaZ which filled the relation which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be above 2 mass %.
[0100] It is desirable that the composition ratio X of Above Co is below 32 mass % above 23 mass %, the composition ratio Y of Fe is below 71 mass % above 58 mass %, and the composition ratio Z of Element alpha fills with this invention the relation it composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be / relation / above 2 mass %.
[0101] Moreover, it is more desirable that the composition ratio X of Above Co is below 28.3 mass % above 23.3 mass %, the composition ratio Y of Above Fe is below 67.5 mass % above 63 mass %, and the composition ratio Z of the aforementioned element alpha fills with this invention the relation it composition ratio X+Y+Z=100 mass % Comes [% / 13.6 mass / below] to be / relation / above 4.2 mass %.
[0102] moreover -- this invention -- the composition ratio Z of the composition ratio Y of the composition ratios X and Fe of Co, and Element alpha (X --) Y and Z= (26.5 mass %, 64.6 mass %, 8.9 mass %) (25.5 mass % --) It is most desirable to fill the relation which composition ratio X+Y+Z=100 mass % Comes to be within the limits surrounded by three points, 23.3 63 mass %, 11.5 mass %, and (mass %, 67.5 mass %, 9.2 mass %).
[0103] Since magnetic flux can be centralized near the gap and recording density can be raised by the aforementioned lower magnetic pole layer 32 and the up magnetic pole layer 34 being formed with the above-mentioned CoFealpha alloy which has the high saturation magnetic flux density Bs beyond 2.0T, manufacture of the thin film magnetic head excellent in high recording density-ization is possible. In addition, as for the aforementioned saturation magnetic flux density Bs, it is more desirable that it is more than 2.2T.
[0104] Moreover, a crystal can be precisely formed by being above-mentioned composition within the limits, and being formed, and the aforementioned CoFealpha alloy can suppress ****** in a film surface, and can raise corrosion resistance. In this invention, Ra can be set to 5nm or less in the center line average coarseness of the aforementioned film surface. Moreover, coercive force Hc can be made small below 1580 (A/m).
[0105] With the operation gestalt shown in drawing 1 or drawing 4 , each has the magnetic pole sections 18 and 30 between the lower core layer 16, the up core layer 22, and 40. The lower magnetic pole layers 19 and 32 and/or the up magnetic pole layers 21 and 34 which constitute the aforementioned magnetic pole sections 18 and 30 The composition ratio X of Co is below 48 mass % above 8 mass %, the composition ratio Y of Fe is below 90 mass % above 50 mass %, and it is Element alpha (however, Element alpha). Although the composition ratio Z of one side of nickel and Cr or both sides is formed by CoXFeYalphaZ which filled the relation which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be above 2 mass % It is desirable that plating formation of the up core layers 22 and 40 which the aforementioned up magnetic pole layers 21 and 34 are especially formed with the aforementioned CoXFeYalphaZ alloy by this invention, and are formed in piles on the aforementioned up magnetic pole layers 21 and 34 is carried out with the NiFe alloy.
[0106] As for the aforementioned up core layers 22 and 40, it is desirable that specific resistance is higher than saturation magnetic flux density Bs rather. Since it is necessary to

suppress that an eddy current loss occurs in the portion of the aforementioned up core layers 22 and 40 in order to draw a record magnetic field suitable for the aforementioned up magnetic pole layers 21 and 34 from the up core layers 22 and 40 at the time of record by the high frequency band, it is effective to use a NiFe alloy with specific resistance higher than a CoFealpha alloy for the up core layers 22 and 40 in this invention when attaining high recording density-ization. In addition, for example, nickel80Fe20 alloy is used for the aforementioned up core layers 22 and 40.

[0107] By the way, although a CoFealpha alloy is used as up magnetic pole layers 21 and 34 and the NiFe alloy is used as up core layers 22 and 40 in this invention, while carrying out plating formation of the aforementioned up core layers 22 and 40 by the electroplating method by this, it can prevent appropriately the aforementioned up magnetic pole layers 21 and 34 being ionized, and beginning to melt.

[0108] The element alpha in this invention is nickel and Cr which make the passive state film used as a precise oxide film, it is that these are added, and it is possible for a passive state film to be formed in the front face of the aforementioned up magnetic pole layers 21 and 34, and to prevent ionization of the up magnetic pole layers 21 and 34.

[0109] Ionization of the up magnetic pole layers 21 and 34 can be suppressed appropriately by this, and the magnetic pole excellent in high saturation magnetic flux density Bs and high corrosion resistance can be maintained.

[0110] In addition, also as for the lower magnetic pole layers 19 and 32, being formed with a CoFealpha alloy is desirable, and they can suppress effectively the ionization of the aforementioned lower magnetic pole layers 19 and 32 when carrying out plating formation of the up core layers 22 and 40 by this.

[0111] Moreover, the laminating of the magnetic layer more than two-layer may be carried out, and the aforementioned lower magnetic pole layers 19 and 32 and/or the up magnetic pole layers 21 and 34 may consist of this inventions. In this composition, it is desirable that the magnetic layer of the side which touches the gap layers 20 and 33 is formed with the CoFealpha alloy of the above-mentioned composition range. It is possible to be able to centralize magnetic flux more near the gap and to manufacture the thin film magnetic head which can respond to future high recording density-ization by this.

[0112] Moreover, although other magnetic layers other than the magnetic layer which touches the aforementioned gap layers 20 and 33 may be formed by the magnetic material of what the quality of the material and a composition ratio, saturation magnetic flux density Bs is smaller than the magnetic layer of the side which touches the aforementioned gap layers 20 and 33, and a bird clapper is desirable, for example, as for a magnetic layer besides the above, being formed with a NiFe alloy is desirable. While becoming possible to draw a record magnetic field suitable for the magnetic layer of the side which touches the gap layers 20 and 33 from a magnetic layer besides the above by this, and to attain high recording density-ization, ionization of the magnetic layer of the side which touches the aforementioned gap layers 20 and 33 when carrying out plating formation of the magnetic layer besides the above can be prevented appropriately.

[0113] In addition, although a magnetic layer besides the above does not need to be formed with a NiFe alloy and it may be formed with a CoFealpha alloy etc., it is desirable to adjust a composition ratio appropriately so that it may have the low saturation magnetic flux density Bs rather than the magnetic layer of the side which touches the gap layers 20 and 33.

[0114] Moreover, although the saturation magnetic flux density Bs of the lower magnetic pole layers 19 and 32 has a desirable high thing, if flux reversal of the leak magnetic field between a lower magnetic pole layer and an up magnetic pole layer is made easy to carry out by making it lower than the saturation magnetic flux density Bs of the up magnetic pole layers 21 and 34, write-in density of the signal to a record medium can be made high more.

[0115] Drawing 5 is drawing of longitudinal section of the thin film magnetic head of the 3rd operation gestalt in this invention. With this operation gestalt, MR head h1 is the same as drawing 1 . As shown in drawing 5 , the magnetic-gap layer (non-magnetic material layer) 41 by the alumina etc. is formed in the lower core layer 16. Furthermore on the aforementioned magnetic-gap layer 41, the coil layer 44 by which pattern formation was carried out so that it

might become spiral superficially through the insulating layer 43 made from a polyimide or resist material is formed. In addition, the aforementioned coil layer 44 is formed with nonmagnetic conductivity material with small electric resistance, such as Cu (copper).
[0116] Furthermore, the aforementioned coil layer 44 is surrounded by the insulating layer 45 formed with a polyimide or resist material, and the up core layer 46 made from soft magnetic materials is formed on the aforementioned insulating layer 45.
[0117] As shown in drawing 5 , in the opposed face with a record medium, it counters through the aforementioned magnetic-gap layer 41 on the lower core layer 16, and, as for point 46a of the aforementioned up core layer 46, the magnetic gap of the magnetic-gap length Gl1 is formed, and end face section 46b of the up core layer 46 is magnetically connected with the lower core layer 16, as shown in drawing 5 .
[0118] In this invention, the lower core layer 16 and/or the up core layer 46 The composition ratio X of Co is below 48 mass % above 8 mass %, the composition ratio Y of Fe is below 90 mass % above 50 mass %, and it is Element alpha (however, Element alpha). The composition ratio Z of one side of nickel and Cr or both sides is formed with the CoXFeYalphaZ alloy which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be above 2 mass % and which fills a relation.
[0119] Moreover, the composition ratio X of Above Co is below 32 mass % above 23 mass %, the composition ratio Y of Fe is below 71 mass % above 58 mass %, and, as for the composition ratio Z of Element alpha, it is desirable to fill the relation which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be above 2 mass %.
[0120] Moreover, it is more desirable that the composition ratio X of Above Co is below 28.3 mass % above 23.3 mass %, the composition ratio Y of Above Fe is below 67.5 mass % above 63 mass %, and the composition ratio Z of the aforementioned element alpha fills with this invention the relation it composition ratio X+Y+Z=100 mass % Comes [% / 13.6 mass / below] to be / relation / above 4.2 mass %.
[0121] moreover -- this invention -- the composition ratio Z of the composition ratio Y of the composition ratios X and Fe of Co, and Element alpha (X --) Y and Z= (26.5 mass %, 64.6 mass %, 8.9 mass %) (25.5 mass % --) It is most desirable to fill the relation which composition ratio X+Y+Z=100 mass % Comes to be within the limits surrounded by three points, 23.3 63 mass %, 11.5 mass %, and (mass %, 67.5 mass %, 9.2 mass %).
[0122] The CoFealpha alloy formed by the above-mentioned composition ratio can obtain the high saturation magnetic flux density Bs beyond 2.15T by the desirable composition ratio by having the saturation magnetic flux density Bs beyond 2.0T, in a more desirable composition ratio, can obtain the high saturation magnetic flux density Bs beyond 2.2T, and can obtain the larger saturation magnetic flux density Bs than 2.2T at the most desirable composition ratio.
[0123] Since magnetic flux can be centralized near the gap and recording density can be raised by the up core layer 46 and/or the lower core layer 16 being formed with the above-mentioned CoFealpha alloy which has the high saturation magnetic flux density Bs beyond 2.0T, manufacture of the thin film magnetic head excellent in high recording density-ization is possible.

[0124] Moreover, a crystal can be precisely formed by being above-mentioned composition within the limits, and being formed, and the aforementioned CoFealpha alloy can suppress ****** in a film surface, and can raise corrosion resistance. In this invention, Ra can be set to 5nm or less in the center line average coarseness of the aforementioned film surface. Moreover, coercive force Hc can be made small. Specifically, the aforementioned coercive force Hc can be made below into 1580 (A/m).
[0125] Moreover, the specific resistance more than 15 (muomega and cm) can be obtained as a CoFealpha alloy is above-mentioned composition within the limits. Moreover, membrane stress can be set to 400 or less MPas. Furthermore about an anisotropy field Hk, the anisotropy field Hk of the same grade as the NiFe alloy currently generally used as soft magnetic materials from the former can be obtained.
[0126] Drawing 6 is drawing of longitudinal section of the thin film magnetic head of the 4th operation gestalt in this invention. The difference from drawing 5 is that the laminating of the up

core layer 46 is carried out, and it consists of two-layer magnetic layers.
[0127] The aforementioned up core layer 46 consists of the upper layers 48 by which the laminating was carried out to the high Bs layer 47 which has the high saturation magnetic flux density Bs on it.
[0128] The composition ratio X of Co is below 48 mass % above 8 mass %, the composition ratio Y of Fe is below 90 mass % above 50 mass %, and the aforementioned quantity Bs layer 47 is formed with the CoXFeYalphaZ alloy with which the composition ratio Z of Element alpha (however, the element alpha one side or the both sides of nickel and Cr) fills the relation which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be above 2 mass %.
[0129] Moreover, the composition ratio X of Above Co is below 32 mass % above 23 mass %, the composition ratio Y of Fe is below 71 mass % above 58 mass %, and, as for the composition ratio Z of Element alpha, it is desirable to fill the relation which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be above 2 mass %.
[0130] Moreover, it is more desirable that the composition ratio X of Above Co is below 28.3 mass % above 23.3 mass %, the composition ratio Y of Above Fe is below 67.5 mass % above 63 mass %, and the composition ratio Z of the aforementioned element alpha fills with this invention the relation it composition ratio X+Y+Z=100 mass % Comes [% / 13.6 mass / below] to be / relation / above 4.2 mass %.
[0131] moreover -- this invention -- the composition ratio Z of the composition ratio Y of the composition ratios X and Fe of Co, and Element alpha (X --) Y and Z= (26.5 mass %, 64.6 mass %, 8.9 mass %) (25.5 mass % --) It is most desirable to fill the relation which composition ratio X+Y+Z=100 mass % Comes to be within the limits surrounded by three points, 23.3 63 mass %, 11.5 mass %, and (mass %, 67.5 mass %, 9.2 mass %).
[0132] Thereby, saturation magnetic flux density Bs of the aforementioned quantity Bs layer 47 is made to at least 2.0 or more. Moreover, Above Bs can be preferably carried out more than 2.15T, Above Bs can be more preferably carried out more than 2.2T, and Above Bs can be most preferably made larger than 2.2T.
[0133] By a crystal being formed precisely, the high Bs layer 47 formed with the aforementioned CoFealpha alloy can make small ****** of the film surface of the aforementioned quantity Bs layer 47, therefore can raise corrosion resistance, and, moreover, can make coercive force Hc small. Specifically, Ra is made to 5nm or less in the center line average coarseness of the aforementioned film surface, and the aforementioned coercive force Hc can be made below into 1580 (A/m). When a CoFealpha alloy is furthermore used, specific resistance is made more than 15 (muomega and cm). Moreover, membrane stress is made to 400 or less MPas.
[0134] Although saturation magnetic flux density Bs is small compared with the high Bs layer 47, as for the upper layer 48 which constitutes the aforementioned up core layer 46, specific resistance is made higher than the aforementioned quantity Bs layer 47. The aforementioned upper layer 48 is formed for example, with nickel80Fe20 alloy.
[0135] Rather than a CoFealpha alloy [in / this invention / in the aforementioned NiFe alloy], although saturation magnetic flux density Bs becomes low, specific resistance becomes high. by this, the aforementioned quantity Bs layer 47 has the saturation magnetic flux density Bs higher than the aforementioned upper layer 48, and concentrates magnetic flux near the gap -- making -- record -- it becomes possible to raise resolution In addition, in this case, although the aforementioned upper layer 48 does not need to be formed with a NiFe alloy and it may be formed with a CoFealpha alloy etc., it is necessary to adjust a composition ratio so that the saturation magnetic flux density Bs of the upper layer 48 may become smaller than the saturation magnetic flux density Bs of the high Bs layer 47.
[0136] Moreover, by the high upper layer 48 of specific resistance having been formed in the aforementioned up core layer 46, loss by the eddy current generated when record frequency rises can be reduced, and the thin film magnetic head which can respond to future high record frequency-ization can be manufactured.
[0137] Moreover, as this invention shows to drawing 6 , it is desirable that the high Bs layer 47 is formed in the gap layer 41 and lower layer side which counters. Moreover, the aforementioned quantity Bs layer 47 may be formed only in point 46a of the up core layer 46 which touches

directly on the gap layer 41.
[0138] Moreover, the lower core layer 16 may also consist of two-layer [of a high Bs layer and a high specific resistance layer]. In this composition, the laminating of the high Bs layer is carried out on a high specific resistance layer, and the aforementioned quantity Bs layer counters with the up core layer 46 through the gap layer 41.
[0139] Moreover, although the up core layer 46 has a two-layer laminated structure with the operation gestalt shown in drawing 6 , you may be three or more layers. As for the high Bs layer 47, in this composition, it is desirable to be formed in the side which touches the magnetic-gap layer 41.
[0140] Moreover, since the high Bs layer 47 is formed with the CoFealpha alloy in this invention, and nickel and the passive state film of Cr are formed in the front face of the aforementioned quantity Bs layer 47 when carrying out plating formation of the upper layer 48 by the electroplating method with a NiFe alloy, the phenomenon of the aforementioned quantity Bs layer 47 being ionized and beginning to melt can be suppressed appropriately.
[0141] Drawing 7 is drawing of longitudinal section of the thin film magnetic head of the 5th operation gestalt in this invention. With the operation gestalt of drawing 7 , the composition of MR head h1 is the same as drawing 1 . As shown in drawing 7 , the bosselation of the lower magnetic pole layer 50 is carried out from the opposed face with a record medium on the lower core layer 16. The insulating layer 51 is formed behind [height direction] the aforementioned lower magnetic pole layer 50 (the direction of illustration Y). The upper surface of the aforementioned insulating layer 51 becomes concave-like, and coil forming face 51a is formed.
[0142] It applies on the aforementioned insulating layer 51 from on the aforementioned lower magnetic pole layer 50, and the gap layer 52 is formed. Furthermore on coil forming face 51a of the aforementioned insulating layer 51, the coil layer 53 is formed through the gap layer 52. The aforementioned coil layer 53 top is covered by the insulating layer 54 made from an organic insulation.
[0143] As shown in drawing 7 , pattern formation is carried out by frame plating, up core applying [55] it on an insulating layer 54 from on the aforementioned gap layer 52.
[0144] On the aforementioned gap layer 52, point 55a of the aforementioned up core layer 55 counters with the lower magnetic pole layer 50, and is formed. End face section 55b of the aforementioned up core layer 55 was formed on the lower core layer 16, is raised, and is magnetically connected to the aforementioned lower core layer 16 through a layer 56.
[0145] In this operation gestalt, the composition ratio X of Co of the up core layer 55 and/or the lower magnetic pole layer 50 is below 48 mass % above 8 mass %. The composition ratio Y of Fe is below 90 mass % above 50 mass %, and the composition ratio Z of Element alpha (however, the element alpha one side or the both sides of nickel and Cr) is formed with the CoXFeYalphaZ alloy which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be above 2 mass % and which fills a relation.
[0146] Moreover, the composition ratio X of Above Co is below 32 mass % above 23 mass %, the composition ratio Y of Fe is below 71 mass % above 58 mass %, and, as for the composition ratio Z of Element alpha, it is desirable to fill the relation which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be above 2 mass %.
[0147] Moreover, it is more desirable that the composition ratio X of Above Co is below 28.3 mass % above 23.3 mass %, the composition ratio Y of Above Fe is below 67.5 mass % above 63 mass %, and the composition ratio Z of the aforementioned element alpha fills with this invention the relation it composition ratio X+Y+Z=100 mass % Comes [% / 13.6 mass / below] to be / relation / above 4.2 mass %.
[0148] moreover -- this invention -- the composition ratio Z of the composition ratio Y of the composition ratios X and Fe of Co, and Element alpha (X --) Y and Z= (26.5 mass %, 64.6 mass %, 8.9 mass %) (25.5 mass % --) It is most desirable to fill the relation which composition ratio X+Y+Z=100 mass % Comes to be within the limits surrounded by three points, 23.3 63 mass %, 11.5 mass %, and (mass %, 67.5 mass %, 9.2 mass %).
[0149] In drawing 7 , if the lower magnetic pole layer 50 is formed and it is formed with the aforementioned CoFealpha alloy which has the saturation magnetic flux density Bs with the

aforementioned lower magnetic pole layer 50 higher than the lower core layer 16, it is possible to be able to centralize magnetic flux near the gap and to aim at improvement in recording density.
[0150] Moreover, although the whole may be formed with the aforementioned CoFealpha alloy, as for the up core layer 55, the side which the aforementioned up core layer 55 is the laminated structure of the magnetic layer more than two-layer, and counters with the gap layer 52 like drawing 6 may be formed by the aforementioned CoFealpha alloy film as a high Bs layer. Moreover, in this case, it is desirable that only point 55a of the aforementioned up core layer 55 is formed by the laminated structure of the magnetic layer more than two-layer, and the high Bs layer is formed in contact with the aforementioned gap layer 52 top, considering the point which is made to concentrate magnetic flux near the gap and raises recording density.
[0151] In addition, as for a CoFealpha alloy film, in each operation gestalt shown in drawing 1 or drawing 7 by this invention, it is desirable that plating formation is carried out. In this invention, plating formation of the aforementioned CoFealpha alloy can be carried out by the electroplating method which used the pulse current.
[0152] Moreover, it becomes possible forming by thick thickness rather than being able to form by arbitrary thickness by carrying out plating formation of the aforementioned CoFealpha alloy and forming by the spatter.
[0153] Moreover, in each operation gestalt, although the layer of a sign 16 is a lower core layer and the combination layer of an up shield layer, the aforementioned lower core layer and the up shield layer may be formed separately. An insulating layer is made to intervene between the aforementioned lower core layer and an up shield layer in this case.
[0154] Next, the general manufacture method of the thin film magnetic head shown in drawing 1 or drawing 7 is explained below.
[0155] The thin film magnetic head shown in drawing 1 and drawing 2 forms the magnetic pole section 18 which consists in the height direction of the lower magnetic pole layer 19, the nonmagnetic gap layer 20, and the up magnetic pole layer 21 by continuation plating from an opposed face with a record medium using a resist, after forming Gd arrangement layer 17 on the lower core layer 16. Next, after forming an insulating layer 23 behind [height direction] the aforementioned magnetic pole section 18, flattening of the upper surface of the aforementioned magnetic pole section 18 and the upper surface of the aforementioned insulating layer 23 is carried out to the same flat surface using CMP technology. After carrying out pattern formation of the coil layer 24 spirally on the aforementioned insulating layer 23, an insulating layer 25 is formed on the aforementioned coil layer 24. And it applies on an insulating layer 25 from on the aforementioned magnetic pole section 18, and the up core layer 22 is formed for example, with frame plating.
[0156] The thin film magnetic head shown in drawing 3 and drawing 4 forms width-of-recording-track formation slot 31a towards the height direction back using a resist from an opposed face with the record medium of the aforementioned insulating layer 31, after forming an insulating layer 31 on the lower core layer 16. Furthermore, the inclined planes 31c and 31c shown in drawing 3 are formed in the aforementioned width-of-recording-track formation slot 31a.
[0157] In the aforementioned width-of-recording-track formation slot 31a, the lower magnetic pole layer 32 and the nonmagnetic gap layer 33 are formed. After forming Gd arrangement layer 37 on an insulating layer 31 from on the aforementioned gap layer 33, plating formation of the up magnetic pole layer 34 is carried out on the aforementioned gap layer 33. Next, after carrying out pattern formation of the coil layer 38 spirally on the aforementioned insulating layer 31, an insulating layer 39 is formed on the aforementioned coil layer 38. And it applies on an insulating layer 39 from on the aforementioned up magnetic pole layer 34, and the up core layer 40 is formed for example, with frame plating.
[0158] After the thin film magnetic head shown in drawing 5 and drawing 6 forms the gap layer 41 on the lower core layer 16 first and forms an insulating layer 43 further, it carries out pattern formation of the coil layer 44 on the aforementioned insulating layer 43. After forming an insulating layer 45 on the aforementioned coil layer 44, it applies on the aforementioned insulating layer 45 from the gap layer 41, and pattern formation of the up core layer 46 is carried out with frame plating.

[0159] First, on the lower core layer 16, a resist is used for the thin film magnetic head shown in drawing 7 , it forms the lower magnetic pole layer 50, and forms an insulating layer 51 behind [height direction] the aforementioned lower magnetic pole layer 50 further. Once flattening of the upper surface of the aforementioned lower magnetic pole layer 50 and the aforementioned insulating layer 51 is carried out by CMP technology, it forms in the upper surface of the aforementioned insulating layer 51 coil forming face 51a which becomes concave-like. Next, after forming the gap layer 52 on the aforementioned insulating layer 51 from on the aforementioned lower magnetic pole layer 50, pattern formation of the coil layer 53 is spirally carried out on the aforementioned gap layer 52, and an insulating layer 54 is further formed on the aforementioned coil layer 53. And it applies on an insulating layer 54 from on the aforementioned gap layer 52, and pattern formation of the up core layer 55 is carried out for example, with frame plating.
[0160] Next, the plating forming method of a CoXFeYalphaZ alloy in this invention the composition ratio X of Co is below 48 mass % above 8 mass %, the composition ratio Y of Fe is below 90 mass % above 50 mass %, and the composition ratio Z of Element alpha (however, the element alpha one side or the both sides of nickel and Cr) fills the relation which composition ratio X+Y+Z=100 mass % Comes [% / 20 mass / below] to be above 2 mass % is explained below.
[0161] In this invention, plating formation of the aforementioned CoFealpha alloy is carried out by the electroplating method which used the pulse current.
[0162] By the electroplating method using the pulse current, ON/OFF of a current controlling element is repeated, for example, and time to pass current at the time of plating formation and blank time not to pass current are prepared. Thus, it is possible to carry out plating formation of the CoFealpha alloy film little by little, to compare by preparing time not passing current, when a direct current is used like before, even if it increased the concentration of Fe ion occupied to a plating bath, and to ease the bias of a distribution of the current density at the time of plating formation.
[0163] In addition, as for a pulse current, it is desirable to repeat ON/OFF for example, in several second cycle, and to make a duty ratio about into 0.1 to 0.5. The conditions of a pulse current affect Ra in the diameter of average crystal grain of a CoFealpha alloy, and the center line average coarseness of a film surface.
[0164] As mentioned above, by the electroplating method by the pulse current, since the bias of a distribution of the current density at the time of plating formation can be eased, it becomes possible to increase conventionally Fe content contained in a CoFealpha alloy compared with the electroplating method by the direct current.
[0165] In this invention, it compares with the electroplating method using the conventional direct current by the electroplating method by the aforementioned pulse current. The flexibility of adjustment of a composition ratio can adjust easily the composition ratio X of Co of increase and a CoFealpha alloy to below 48 mass % above 8 mass %. It is possible to be able to adjust the composition ratio Y of Fe to below 90 mass % easily above 50 mass %, and to adjust the composition ratio Z of Element alpha to below 20 mass % easily above 2 mass %.
[0166] The composition ratio X of Above Co by limiting plating bath composition as follows in this invention above 23 mass % Moreover, below 32 mass % With the CoFealpha alloy which the composition ratio Z of below 71 mass % and Element alpha was made to below 20 mass % above 2 mass % above 58 mass %, and was formed by this composition ratio, the composition ratio Y of Fe Saturation magnetic flux density Bs is made more than 2.15T, moreover, Ra is made to 5nm or less in the center line average coarseness of a film surface, it has high saturation magnetic flux density effectively, and the soft-magnetism film which was moreover excellent in corrosion resistance can be manufactured.
[0167] In this invention, the ratio of Fe ion concentration / Co ion concentration is made or more into 1.5, and the ratio of Fe ion concentration / alpha ion concentration is made or less into four two or more. As shown in the below-mentioned experimental result, Fe composition ratio of a CoFealpha alloy is made to below 71 mass % above 58 mass % as it is the above-mentioned ratio, and Co composition ratio is made to below 32 mass % above 23 mass %.
[0168] When it is the plating bath composition from which it separates from the ratio of the

above-mentioned ion concentration, the amount of Fe(s) may be less than 50 mass %, the saturation magnetic flux density Bs beyond 2.0T cannot be obtained, it is stabilized, and it becomes impossible on the other hand, to obtain the high saturation magnetic flux density Bs. Furthermore, Ra may become larger than 5nm in the center line average coarseness of a film surface, and corrosion resistance may get worse.

[0169] Moreover, it is desirable it to be desirable that it is lower than before as for Fe ion concentration, and to specifically be set up by 2.0 or less g/l in this invention, at 1.0 or more g/l. making it low concentration, although the aforementioned Fe ion concentration was about 4.0 g/l in the former -- the stirring effect -- it can raise -- a twist -- while being able to enlarge Fe content of a CoFealpha alloy appropriately, a precise crystal can be formed, and it can be made the CoFealpha alloy excellent in corrosion resistance

[0170] Moreover, in this invention, Fe ion concentration / Co ion concentration under plating bath are made or more into 1.5. Fe ion concentration / alpha ion concentration is made or less into 3.4 by two or more, and the composition ratio X of Co is below 28.3 mass % above 23.3 mass %. the composition ratio Y of Above Fe It is below 67.5 mass % above 63 mass %, and, as for the composition ratio Z of the aforementioned element alpha, it is desirable to carry out plating formation of the CoXFeYalphaZ alloy film which composition ratio X+Y+Z=100 mass % Comes [% / 13.6 mass / below] to be and which fills a relation above 4.2 mass %.

[0171] With the CoFealpha alloy formed by this composition ratio, saturation magnetic flux density Bs is made more than 2.2T, moreover, Ra is made to 5nm or less in the center line average coarseness of a film surface, it has high saturation magnetic flux density effectively, and the soft-magnetism film which was moreover excellent in corrosion resistance can be manufactured.

[0172] Moreover, in this invention, Fe ion concentration / Co ion concentration under plating bath are made or more into 1.7. Fe ion concentration / alpha ion concentration is made or less into 3.4 by two or more. The composition ratio X of Co the composition ratio Y of Fe, and the composition ratio of Element alpha -- Z= (X, Y, Z) (26.5 mass % --) 64.6 mass % and 8.9 mass % (25.5 mass % and 63 mass % --) It is most desirable to carry out plating formation of the CoXFeYNiZ alloy film which composition ratio X+Y+Z=100 mass % Comes to be within the limits surrounded by three points, 23.3 11.5 mass %, and (mass %, 67.5 mass %, 9.2 mass %), and which fills a relation.

[0173] With the CoFealpha alloy formed by this composition ratio, saturation magnetic flux density Bs can be made larger than 2.2T, moreover, Ra is made to 5nm or less in the center line average coarseness of a film surface, it has high saturation magnetic flux density effectively, and the soft-magnetism film which was moreover excellent in corrosion resistance can be manufactured. It is checked that 66.1 mass % and the composition ratio of Co can be made by the composition ratio of Fe, and 24.6 mass % and the composition ratio of Element alpha can make 9.3 mass %, then saturation magnetic flux density Bs large even to 2.25T especially.

[0174] Moreover, it is desirable to mix a saccharin sodium (C6H4CONNaSO2) during the plating bath of a CoFealpha alloy in this invention. The aforementioned saccharin sodium has the role of a stress relaxation agent, and it becomes possible to reduce the membrane stress of the CoFealpha alloy by which plating formation was carried out. In addition, if nickel is chosen as Element alpha, it is possible to reduce membrane stress more.

[0175] Moreover, it is desirable to mix the 2-butyne -1 and four diols during the plating bath of the above-mentioned CoFealpha alloy. Big and rough-ization of the diameter of crystal grain of the aforementioned CoFealpha alloy can be suppressed by this, and coercive force Hc can be reduced.

[0176] Moreover, it is desirable to mix a 2-ethylhexyl sodium sulfate during the plating bath of the aforementioned CoFealpha alloy in this invention.

[0177] The aforementioned 2-ethylhexyl sodium sulfate is a surfactant. It can prevent that can remove the hydrogen generated at the time of plating formation of a CoFealpha alloy, and the aforementioned hydrogen adheres to a plating film by mixing of the aforementioned 2-ethylhexyl sodium sulfate. If hydrogen adheres to the aforementioned plating film, since it will become the cause which a crystal is not formed precisely, consequently makes ****** of a film surface

severe, it is possible to be able to make small ****** of the film surface of the aforementioned plating film, and to make coercive force Hc small by removing the aforementioned hydrogen like this invention.
[0178] In addition, although it may replace with the aforementioned 2-ethylhexyl sodium sulfate and a sodium lauryl sulfate may be mixed, since it is easy to foam when it puts in during a plating bath compared with the aforementioned 2-ethylhexyl sodium sulfate, it is difficult for the aforementioned sodium lauryl sulfate to mix the aforementioned sodium lauryl sulfate in the grade which can remove hydrogen effectively. For this reason, in this invention, the 2-ethylhexyl sodium sulfate which cannot foam easily compared with the aforementioned sodium lauryl sulfate can be mixed in the grade which can remove hydrogen effectively, and it is desirable.
[0179] Moreover, it is desirable to mix a boric acid during the aforementioned plating bath. The boric acid is effective for becoming a buffer for pH on the front face of an electrode, and taking out the gloss of a plating film.
[0180] In addition, although the thin film magnetic head shown in drawing 1 or drawing 7 as a use of a CoFealpha alloy was shown in this invention, it is not limited to this use. For example, the aforementioned CoFealpha alloy is usable to flat-surface type magnetic cells, such as a thin film inductor, etc.
[0181]
[Example] In this invention, plating formation of the CoFeNi alloy was carried out using the electroplating method by the pulse current from the plating bath shown below, and it investigated about the relation between the composition ratio of the aforementioned CoFeNi alloy, soft magnetic characteristics, and a film property at this time.
[0182] First, the ratio of Fe ion concentration / Co ion concentration is smaller than 1.5, and plating bath composition in case the ratio of Fe ion concentration / nickel ion concentration becomes small rather than 2 is shown in the following table 1.
[0183]
[Table 1]
Feイオン/Coイオンが1.5よりも小で、Feイオン/Niイオンが2よりも小の浴

Feイオン	2.0	g/l
Coイオン	1.35	g/l
Niイオン	2.23	g/l
サッカリンナトリウム	0.8	g/l
2−エチルヘキシル硫酸ナトリウム	0.15	g/l
2−ブチン−1, 4−ジオール	1	g/l
ほう酸	25	g/l
塩化ナトリウム	25	g/l

[0184] In the plating bath shown in Table 1, Fe ion concentration was made into 2 g/l, and nickel ion concentration was further made into 2.23 g/l for Co ion concentration 1.35 g/l. Moreover, the saccharin sodium of the amount displayed on the plating bath by Table 1, a 2-ethylhexyl sodium sulfate, the 2-butyne -1, 4-diol, the boric acid, and the sodium chloride were added.
[0185] Next, plating bath composition in case the ratio of Fe ion concentration / Co ion concentration becomes [the ratio of Fe ion concentration / nickel ion concentration] smaller than 2 or more by 1.5 is shown in the following table 2.
[0186]
[Table 2]

Feイオン／Coイオンが1.5以上で、Feイオン／Niイオンが2よりも小の浴

Feイオン	2.0、3.72	g/l
Coイオン	1.26、2.38	g/l
Niイオン	2.0、3.29	g/l
サッカリンナトリウム	0.6、1.2	g/l
2−エチルヘキシル硫酸ナトリウム	0.15、0.4	g/l
2−ブチン−1, 4−ジオール	0、1.6	g/l
ほう酸	25	g/l
塩化ナトリウム	25	g/l

[0187] In the plating bath shown in Table 2, Fe ion concentration was made into 2 g/l, and nickel ion concentration was further made into 2 g/l for Co ion concentration 1.26 g/l. Moreover, in other plating baths, Fe ion concentration was made into 3.72 g/l, and nickel ion concentration was further made into 3.29 g/l for Co ion concentration 2.38 g/l. Moreover, two or more plating baths which are different as the addition of a saccharin sodium, a 2-ethylhexyl sodium sulfate, the 2-butyne -1, and 4-diol is shown in a table were made from each above-mentioned plating bath. And the CoFeNi alloy was manufactured from each plating bath composition of two or more.
[0188] Next, the ratio of Fe ion concentration / Co ion concentration is shown in Table 3 of the following [composition / plating bath / in case the ratio of Fe ion concentration / nickel ion concentration becomes four or less or more by 1.5 two or more].
[0189]
[Table 3]
Feイオン／Coイオンが1.5以上で、Feイオン／Niイオンが2以上4以下の浴

Feイオン	1.17、1.29、1.41、1.61、1.81	g/l
Coイオン	0.57、0.69、0.73、0.87	g/l
Niイオン	0.35、0.45、0.49、0.54	g/l
サッカリンナトリウム	0.8、1.2	g/l
2−エチルヘキシル硫酸ナトリウム	0.15、0.3	g/l
2−ブチン−1, 4−ジオール	0、1.2	g/l
ほう酸	25	g/l
塩化ナトリウム	25	g/l

[0190] In the plating bath shown in Table 3, Fe ion concentration was made into 1.17 g/l, and nickel ion concentration was further made into 0.35 g/l for Co ion concentration 0.57 g/l. In other plating baths, Fe ion concentration was made into 1.17 g/l, and nickel ion concentration was further made into 0.45 g/l for Co ion concentration 0.73 g/l. Moreover, in other plating baths, Fe ion concentration was made into 1.29 g/l, and nickel ion concentration was made into 0.45 g/l or 0.49 g/l for Co ion concentration at 0.73 g/l or 0.87, and the pan. moreover -- other plating baths -- Fe ion concentration -- 1.41 g/l and Co ion concentration -- 0.87 g/l -- or nickel ion concentration was further made into 0.54 g/l or 0.35 g/l 0.69 g/l Moreover, in other plating baths, Fe ion concentration was made into 1.61 g/l, and nickel ion concentration was further made into 0.54 g/l for Co ion concentration 0.87 g/l. Moreover, in other plating baths, Fe ion concentration was made into 1.81 g/l, and nickel ion concentration was further made into 0.54 g/l for Co ion concentration 0.87 g/l. Moreover, two or more plating baths which are different as the addition of a saccharin sodium, a 2-ethylhexyl sodium sulfate, the 2-butyne -1, and 4-diol is shown in a table were made from each above-mentioned plating bath. And the CoFeNi alloy was manufactured from each plating bath composition of two or more.
[0191] Next, the ratio of Fe ion concentration / Co ion concentration is shown in Table 4 of the following [composition / plating bath / in case the ratio of Fe ion concentration / nickel ion concentration becomes 3.4 or less or more by 1.5].

[0192]
[Table 4]
Fe イオン／Co イオンが 1.5 以上で、Fe イオン／Ni イオンが 3.4 以下の浴

Fe イオン	1.17、1.29、1.60、1.81	g／l
Co イオン	0.73、0.87	g／l
Ni イオン	0.45、0.49、0.54	g／l
サッカリンナトリウム	1.2	g／l
2－エチルヘキシル硫酸ナトリウム	0.3	g／l
2－ブチン－1, 4－ジオール	1.2	g／l
ほう酸	25	g／l
塩化ナトリウム	25	g／l

[0193] Next, the ratio of Fe ion concentration / Co ion concentration is shown in Table 5 of the following [composition / plating bath / in case the ratio of Fe ion concentration / nickel ion concentration becomes 3.4 or less or more by 1.7].
[0194]
[Table 5]
Fe イオン／Co イオンが 1.7 以上で、Fe イオン／Ni イオンが 3.4 以下の浴

Fe イオン	1.29、1.60、1.81	g／l
Co イオン	0.73、0.87	g／l
Ni イオン	0.45、0.49、0.54	g／l
サッカリンナトリウム	1.2	g／l
2－エチルヘキシル硫酸ナトリウム	0.3	g／l
2－ブチン－1, 4－ジオール	1.2	g／l
ほう酸	25	g／l
塩化ナトリウム	25	g／l

[0195] Next, the ratio of Fe ion concentration / Co ion concentration is shown in Table 6 of the following [composition / plating bath / in case the ratio of Fe ion concentration / nickel ion concentration becomes 3.0 or less by 1.8].
[0196]
[Table 6]
Fe イオン／Co イオンが 1.8 の浴、Fe イオン／Ni イオンが 3.0 以下の浴

Fe イオン	1.6	g／l
Co イオン	0.87	g／l
Ni イオン	0.54	g／l
サッカリンナトリウム	1.2	g／l
2－エチルヘキシル硫酸ナトリウム	0.3	g／l
2－ブチン－1, 4－ジオール	1.2	g／l
ほう酸	25	g／l
塩化ナトリウム	25	g／l

[0197] Next, plating bath composition in case the ratio of Fe ion concentration / Co ion concentration becomes [the ratio of Fe ion concentration / nickel ion concentration] larger than 4 or more by 1.5 is shown in the following table 7.
[0198]
[Table 7]

Feイオン／Coイオンが1.5以上で、Feイオン／Niイオンが4よりも大の浴

Feイオン	1.17	g／l
Coイオン	0.73	g／l
Niイオン	0.11	g／l
サッカリンナトリウム	1.2	g／l
2ーエチルヘキシル硫酸ナトリウム	0.3	g／l
2ーブチンー1, 4ージオール	1.2	g／l
ほう酸	25	g／l
塩化ナトリウム	25	g／l

[0199] Moreover, when carrying out plating formation of the CoFeNi alloy from plating bath composition of Table 1 or 7, the following membrane formation conditions were carried out in common.
[0200] The degree of plating bath temperature was first set as 30 degrees C. Moreover, pH of an electrode was set as 2.8. Moreover, current density was set as 46.8 mA/cm2. Furthermore, the dee tea ratio (ON/OFF) of a pulse current was set as 400/1000msec. Moreover, Fe electrode was used for the electrode by the side of an anode.
[0201] It was as [property / the soft magnetic characteristics and the film property / by which plating formation was carried out by each plating bath composition of Table 1 or 7 / of a CoFeNi alloy] follows.
[0202]
[Table 8]

Fe組成	52.8［質量%］以上、53.2［質量%］以下
Co組成	30.3［質量%］以上、32.2［質量%］以下
Bs	2.09～2.10
面粗さ	1.6［nm］以上、2.9［nm］以下
膜応力	212［MPa］以上、235［MPa］以下

[0203] Table 8 is the experimental result of Table 1, namely, is an experimental result at the time of making the ratio of Fe ion concentration / Co ion concentration smaller than 1.5, and making Fe ion concentration / nickel ion concentration smaller than 2.
[0204] As shown in Table 8, the composition ratio of Fe of a CoFeNi alloy became below 53.2 mass % above 52.8 mass %, and the composition ratio of Co became below 32.2 mass % above 30.3 mass %.
[0205] Moreover, as shown in Table 8, about Ra, it was able to be set to 2.9nm or less by 1.6nm or more in the center line average coarseness of a film surface, and the good value was able to be acquired. Moreover, the saturation magnetic flux density Bs beyond 2.0T could be obtained, and the variation in a value was also small. However, the maximum of Above Bs was 2.1T.
[0206] In Table 8, the thing with the small variation in saturation magnetic flux density Bs is considered because crystallinity is good, when Ra is 2.9nm or less in 1.6nm or more. However, it is considered to be in that there are few amounts of Fe(s) that Above Bs does not exceed 2.2T.
[0207]
[Table 9]

Fe組成	52.3［質量%］以上、56.1［質量%］以下
Co組成	30.7［質量%］以上、30.8［質量%］以下
Bs	2.07～2.14
面粗さ	2.9［nm］以上、3.5［nm］以下
膜応力	235［MPa］以上、291［MPa］以下

[0208] Table 9 is the experimental result of Table 2, namely, is an experimental result at the time of making the ratio of Fe ion concentration / Co ion concentration or more into 1.5, and making Fe ion concentration / nickel ion concentration smaller than 2.
[0209] As shown in Table 9, the composition ratio of Fe of a CoFeNi alloy became below 56.1 mass % above 52.3 mass %, and the composition ratio of Co became below 30.8 mass % above 30.7 mass %.
[0210] Moreover, as shown in Table 9, about Ra, it was set to 3.5nm or less by 2.9nm or more in the center line average coarseness of a film surface. Moreover, about saturation magnetic flux density Bs, 2T were exceeded, and it was set to 2.14T at the maximum, and became larger than the case of Table 8. However, the variation in saturation magnetic flux density was large. It is thought of because Ra was set to 3.5nm or less by 2.9nm or more and crystallinity fell by the bird clapper greatly compared with Table 8 that the variation in saturation magnetic flux density Bs becomes large. Moreover, although it is thought of because the amount of Fe(s) became large a little that saturation magnetic flux density became large rather than Table 8, it is thought that Fe insufficient shell and saturation magnetic flux density Bs do not still exceed 2.2T.
[0211]
[Table 10]

Fe 組成	58 [質量%] 以上、71 [質量%] 以下
Co 組成	23 [質量%] 以上、32 [質量%] 以下
Ni 組成	2 [質量%] 以上、20 [質量%] 以下
Bs	2.16 [T] 以上、2.25 [T] 以下
面粗さ	2.3 [nm] 以上、5 [nm] 以下
膜応力	18 [MPa] 以上、400 [MPa] 以下

[0212] Table 10 is the experimental result of Table 3, namely, is an experimental result at the time of making the ratio of Fe ion concentration / Co ion concentration or more into 1.5, and making Fe ion concentration / nickel ion concentration or less into four by two or more.
[0213] As shown in Table 10, the composition ratio of Fe of a CoFeNi alloy became below 71 mass % above 58 mass %, and the composition ratio of Co became below 32 mass % above 23 mass %.
[0214] Moreover, as shown in Table 10, saturation magnetic flux density Bs is less than [2.25T] more than in 2.16T, and was able to obtain about [that saturation magnetic flux density Bs always exceeds 2.0T] or the high saturation magnetic flux density beyond 2.15T.
[0215] Moreover, Ra was able to be set to 5nm or less by 2.3nm or more in the center line average coarseness of a film surface, and it was able to suppress appropriately also about ******.
[0216] Thus, since Ra could also be held down to 5nm or less in the center line average coarseness of about [that the very high saturation magnetic flux density Bs exceeding 2.15T is obtained in Table 10] and a film surface and the good result was obtained compared with Table 8 and 9 In this invention, we decided to make into the desirable composition range plating bath composition which made the ratio of Fe ion concentration / Co ion concentration 1.5 or more, and made Fe ion concentration / nickel ion concentration four or less or more by two.
[0217]
[Table 11]

Fe 組成	63.1 [質量%] 以上、67.5 [質量%] 以下
Co 組成	23.3 [質量%] 以上、28.3 [質量%] 以下
Ni 組成	4.2～13.6 [質量%]
Bs	2.2 [T] 以上、2.25 [T] 以下
面粗さ	2.7 [nm] 以上、5 [nm] 以下
膜応力	168 [MPa] 以上、400 [MPa] 以下

[0218] Table 11 is the experimental result of Table 4, namely, is an experimental result at the time of making the ratio of Fe ion concentration / Co ion concentration or more into 1.5, and making Fe ion concentration / nickel ion concentration or less into 3.4 by two or more.
[0219] As shown in Table 11, the composition ratio of Fe was below 67.5 mass % above 63 mass %, and the composition ratio of Co was below 28.3 mass % above 23.3 mass %, and the composition ratio of nickel was below 13.6 mass % above 4.2 mass %.
[0220] As shown in Table 11, saturation magnetic flux density Bs is less than [2.25T] more than in 2.2T, and was understood that it is possible to always obtain the high saturation magnetic flux density Bs beyond 2.2T. Moreover, Ra was also 5nm or less in 2.7nm or more in the center line average coarseness of a film surface, and ****** was small.
[0221] Therefore, in this invention, we decided to make into the more desirable composition range plating bath composition which made the ratio of Fe ion concentration / Co ion concentration 1.5 or more, and made Fe ion concentration / nickel ion concentration 3.4 or less or more by two.
[0222]
[Table 12]

Fe 組成	63.0	64.6	67.5
Co 組成	25.5	26.5	23.3
Ni 組成	11.5	8.9	9.2
Bs	2.2 [T]よりも大、2.25 [T]以下		
面粗さ	2.7 [nm]以上、5 [nm]以下		
膜応力	329 [MPa]以上、400 [MPa]以下		

[0223] Table 12 is the experimental result of Table 5, namely, is an experimental result at the time of making the ratio of Fe ion concentration / Co ion concentration or more into 1.7, and making Fe ion concentration / nickel ion concentration or less into 3.4 by two or more.
[0224] As shown in Table 12, the composition ratio of Fe is below 67.5 mass % above 63 mass %, and the composition ratio of Co is **** below in 26.5 mass % above 23.3 mass %. In addition, it sets on 3 original drawings and, for the composition ratio of Fe, 64.6 mass % and the composition ratio of Co are [each composition ratio of Fe, Co, and nickel] 26.5 mass %. For the point that the composition ratio of nickel becomes 8.9 mass %, and the composition ratio of Fe, 63 mass % and the composition ratio of Co are 25.5 mass %. For the point that the composition ratio of nickel becomes 11.5 mass %, and the composition ratio of Fe, 67.5 mass % and the composition ratio of Co are 23.3 mass %. It is composition within the limits surrounded by a total of three of the points that the composition ratio of nickel becomes 9.2 mass %.
[0225] As shown in Table 12, saturation magnetic flux density Bs became less than [2.25T] from 2.2T greatly, and was understood that it is possible to obtain the always larger saturation magnetic flux density Bs than 2.2T compared with the case of Table 11. Moreover, Ra was also 5nm or less in 2.7nm or more in the center line average coarseness of a film surface, and ****** was small.
[0226] Therefore, in this invention, we decided to make into the most desirable composition range plating bath composition which made the ratio of Fe ion concentration / Co ion concentration 1.7 or more, and made Fe ion concentration / nickel ion concentration 3.4 or less or more by two.
[0227]
[Table 13]

Fe 組成	66.1 [質量%]
Co 組成	24.6 [質量%]
Bs	2.25 [T]
面粗さ	2.7 [nm]
膜応力	359 [MPa]

[0228] Table 13 is the experimental result of Table 6, namely, is an experimental result at the time of setting the ratio of Fe ion concentration / Co ion concentration to 1.8, and making Fe ion concentration / nickel ion concentration or less into three by two or more.
[0229] As shown in Table 13, the composition ratio of Fe was 66.1 mass %, and the composition ratio of Co was 24.6 mass %, and the composition ratio of nickel was 9.3 mass %.
[0230] As shown in Table 13, saturation magnetic flux density Bs was able to obtain 2.25T and very high saturation magnetic flux density. Moreover, Ra was also 2.7nm in the center line average coarseness of a film surface, and ****** was small.
[0231]
[Table 14]

Fe 組成	72 [質量%]
Co 組成	25.6 [質量%]
Ni 組成	2.4 [質量%]
Bs	2.15 [T]
面粗さ	5.4 [nm]
膜応力	387 [MPa]

[0232] Table 14 is the experimental result of Table 7, namely, is an experimental result at the time of making the ratio of Fe ion concentration / Co ion concentration or more into 1.5, and making Fe ion concentration / nickel ion concentration larger than 4.
[0233] As shown in Table 14, the composition ratio of Fe of a CoFeNi alloy was 72 mass %, and 25.6 mass % and the composition ratio of nickel of the composition ratio of Co were 2.4 mass %s.

[0234] Although the high saturation magnetic flux density Bs which saturation magnetic flux density Bs is set to 2.15T as shown in Table 14, and exceeds 2.0T was able to be obtained, Ra was set to 5.4nm in the center line average coarseness of a film surface, it became larger than 5nm, and ****** became large.
[0235] The reason ****** becomes large is considered to be in the ratio of Fe ion concentration / nickel ion concentration being higher than other plating baths of Table 1 or 6, as shown in plating bath composition of Table 7.
[0236] It becomes the unusual deposit in which Fe deposits in dominance that Fe ion concentration is a value large enough compared with nickel ion concentration, and the diameter of crystal grain turns big and rough, and cannot form a precise film, but is considered that ****** of a film surface becomes large.
[0237] Moreover, about the ability of ****** to be suppressed, the size of the Fe ion concentration itself also involves greatly. As for the aforementioned Fe ion concentration, in this invention, it is desirable that it is 1.0 g/l - 2.0 g/l. In addition, in the former, Fe ion concentration was about 4.0 g/l. It is possible to be able to raise the stirring effect by making Fe ion concentration into low concentration conventionally like this invention, to be able to make the diameter of crystal grain small, while being able to increase the amount of Fe(s) contained in a CoFeNi alloy, to be able to form a precise film, and to suppress ******.
[0238] Moreover, by mixing the 2-butyne -1 and four diols during a plating bath, big and rough-ization of the diameter of crystal grain of a CoFeNi alloy by which plating formation was carried out can be suppressed, the aforementioned diameter of crystal grain is small, it is hard coming to generate an opening between crystals in a bird clapper, and ****** of a film surface can be

suppressed.
[0239] Next, the relation with the amount of Fe(s) of each CoFeNi alloy, the soft magnetic characteristics, and the film property which were acquired in the above-mentioned experiment was measured, and it collected into below. Moreover, it investigated about the relation with the amount of Fe(s), the soft magnetic characteristics, and the film property which are included in a NiFe alloy also about a NiFe alloy. Moreover, plating formation of the aforementioned NiFe alloy was carried out by the electroplating method using the pulse current on the same conditions as the time of carrying out plating formation of the CoFeNi alloy.
[0240] Drawing 8 is 3 original drawings showing the relation between the composition ratio of a CoFeNi alloy, and saturation magnetic flux density Bs.
[0241] As shown in drawing 8 , (3 On nickel composition shaft of original drawing), all are less than [1.9T] and, as for the saturation magnetic flux density Bs of a NiFe alloy, are known by not exceeding 2.0T. Moreover, ** mark also showed the relation between the composition ratio of the CoFeNi alloy shown in Table 2 of JP,10-199726,A, and saturation magnetic flux density Bs on 3 original drawings.
[0242] There are few amounts of Fe(s), and it is a 30 mass % grade at the maximum, and, as for the CoFeNi alloy shown in Table 2 of JP,10-199726,A, saturation magnetic flux density Bs is also known by that it is about 1.8T at the maximum, and is not over 2.0T.
[0243] In this invention, by carrying out the amount of Fe(s) of a CoFeNi alloy more than 50 mass % showed that saturation magnetic flux density Bs was made more than 2.0T by this experiment.
[0244] Moreover, if the amount of Fe(s) is too large not much, while big and rough-ization of the diameter of crystal grain will become remarkable and ****** of a film surface will become severe shortly, saturation magnetic flux density Bs also falls. When the amount of Fe(s) exceeded 90 mass %, it turns out that saturation magnetic flux density Bs is less than 2.0T.
[0245] Next, when 20 mass % was exceeded about the amount of nickel, it turns out that saturation magnetic flux density Bs is less than 2.0T. Moreover, if the amount of nickel was not 2 mass % Applied, while membrane stress will become very large and film peeling will become easy to produce it at worst, it turns out that the passive state film as a precise oxide film is also hard to be formed in the front face of a CoFeNi alloy.
[0246] the composition ratio of the CoFeNi alloy in this invention from the above-mentioned experimental result -- the range of Co(es), i.e., amount, in the slash of ** of drawing 8 -- the amount of nickel carried out [the amount of Fe(s)] to below 20 mass % below 90 mass % below 48 mass % above 2 mass % above 50 mass % above 8 mass % If it is this within the limits, saturation magnetic flux density Bs of a CoFeNi alloy will be made more than 2.0T.
[0247] Moreover, in this invention, it considered as composition within the limits surrounded with the alternate long and short dash line of ** shown in drawing 8 as a desirable range. This composition within the limits is the composition range of the CoFeNi alloy formed by plating bath composition of already explained Table 3. That is, for the amount of Co(es), the amount of Fe(s) is [the amount of nickel] below 20 mass % below 71 mass % below 32 mass % above 2 mass % above 58 mass % above 23 mass %. Saturation magnetic flux density Bs is made more than 2.15T as it is this composition within the limits, and the still higher saturation magnetic flux density Bs can be obtained.
[0248] And since big and rough-ization of the diameter of crystal grain is suppressed and a precise film is formed, ****** of a film surface can be suppressed appropriately and it is possible to hold down Ra to 5nm or less in the center line average coarseness of a film surface.
[0249] Moreover, in this invention, it considered as composition within the limits surrounded by the dotted line of ** shown in drawing 8 as a more desirable range. This composition within the limits is the composition range of the CoFeNi alloy formed by plating bath composition of already explained Table 4. That is, the composition ratio X of Above Co is below 28.3 mass % above 23.3 mass %, the composition ratio Y of Above Fe is below 67.5 mass % above 63 mass %, and the composition ratio Z of the aforementioned element alpha is below 13.6 mass % above 4.2 mass %. Saturation magnetic flux density Bs is made more than 2.2T as it is this composition within the limits, and the still higher saturation magnetic flux density Bs can be obtained.

[0250] And since big and rough-ization of the diameter of crystal grain is suppressed and a precise film is formed, ****** of a film surface can be suppressed appropriately and it is possible to hold down Ra to 5nm or less in the center line average coarseness of a film surface.
[0251] Moreover, in this invention, it considered as composition within the limits surrounded by the dotted line of ** shown in drawing 8 as most desirable range. This composition within the limits is the composition range of the CoFeNi alloy formed by plating bath composition of already explained Table 5. That is, the composition ratio Z of the composition ratio Y of the composition ratios X and Fe of Co and Element alpha is within the limits surrounded by three points, 25.5 = (X, Y, Z) (26.5 mass %, 64.6 mass %, 8.9 mass %), (mass %, 63 mass %, 11.5 mass %), and (23.3 mass %, 67.5 mass %, 9.2 mass %). Saturation magnetic flux density Bs can be made larger than 2.2T as it is this composition within the limits, and the still higher saturation magnetic flux density Bs can be obtained.
[0252] And since big and rough-ization of the diameter of crystal grain is suppressed and a precise film is formed, ****** of a film surface can be suppressed appropriately and it is possible to hold down Ra to 5nm or less in the center line average coarseness of a film surface.
[0253] Next, other soft magnetic characteristics or film properties of a CoFeNi alloy which are composition within the limits of ** shown in drawing 8 or **, and were formed are explained henceforth [drawing 9].
[0254] Drawing 9 is 3 original drawings showing the relation between the composition ratio of a CoFeNi alloy, and coercive force. In composition within the limits of ** shown in drawing 9 , or **, it turns out that coercive force Hc can be held down to 158 or less A/m. Although this numeric value becomes larger than a NiFe alloy, a problem is not produced in using a CoFeNi alloy as a magnetic pole of the thin film magnetic head, if coercive force Hc can be held down to 1580 or less A/m.
[0255] Drawing 10 is 3 original drawings showing the relation between the composition ratio of a CoFeNi alloy, and specific resistance. In composition within the limits of ** shown in drawing 10 , or **, it turns out that specific resistance is made more than 15micro ohm-cm. On the other hand, the NiFe alloy could obtain specific resistance higher than it, and was specifically able to obtain the specific resistance more than 35micro ohm-cm.
[0256] For this reason, as already explained, the eddy current loss in the aforementioned up core layer 22 can be stopped by using the CoFeNi alloy in this invention for the up magnetic pole layer 21 of drawing 2 , and using a NiFe alloy for the up core layer 22, magnetic flux can be smoothly passed in the up magnetic pole layer 21 from the aforementioned up core layer 22, and it is possible to aim at appropriately concentration of the magnetic flux to the aforementioned up magnetic pole layer 21.
[0257] Drawing 11 is 3 original drawings showing the relation between the composition ratio of a CoFeNi alloy, and membrane stress. In composition within the limits of ** shown in drawing 11 , or **, it turns out that membrane stress can be held down to 400 or less mPas. Although this numeric value becomes larger than a NiFe alloy, a problem is not produced in using a CoFeNi alloy as a magnetic pole of the thin film magnetic head, if membrane stress can be held down to 400 or less mPas.
[0258]
[Effect of the Invention] In this invention explained in full detail above, the composition ratio X of Co of a CoXFeYalphaZ alloy It carries out to below 48 mass % above 8 mass %, the composition ratio Y of Fe is made below into 90 mass % above 50 mass %, and it is Element alpha (however, Element alpha). on the other hand, there is nickel or Cr -- it is -- both composition ratios Z -- more than 2 mass % -- below 20 mass % -- carrying out -- a composition ratio -- X+Y+Z=100 mass % -- by filling a relation, it is stabilized and the saturation magnetic flux density Bs higher than a NiFe alloy beyond 2.0T can be obtained
[0259] Moreover, it is desirable to fill with this invention the relation which makes the composition ratio X of Above Co below 32 mass % above 23 mass %, makes the composition ratio Y of Fe below 71 mass % above 58 mass %, and composition ratio X+Y+Z=100 mass % Comes it below 20 mass % to carry out the composition ratio Z of Element nickel above 2 mass %.
[0260] Moreover, it is more desirable that the composition ratio X of Above Co is below 28.3

mass % above 23.3 mass %, the composition ratio Y of Above Fe is below 67.5 mass % above 63 mass %, and the composition ratio Z of the aforementioned element alpha fills with this invention the relation it composition ratio X+Y+Z=100 mass % Comes [% / 13.6 mass / below] to be / relation / above 4.2 mass %.

[0261] moreover -- this invention -- the composition ratio Z of the composition ratio Y of the composition ratios X and Fe of Co, and Element alpha (X --) Y and Z= (26.5 mass %, 64.6 mass %, 8.9 mass %) (25.5 mass % --) It is most desirable to fill the relation which composition ratio X+Y+Z=100 mass % Comes to be within the limits surrounded by three points, 23.3 63 mass %, 11.5 mass %, and (mass %, 67.5 mass %, 9.2 mass %).

[0262] Moreover, since it is nickel and Cr from which Element alpha makes a passive state film in the case of the CoFealpha alloy in this invention, the phenomenon of the aforementioned CoFealpha alloy ionizing and beginning to melt into the aforementioned CoFealpha alloy even if it carries out plating formation of the NiFe alloy in piles can be prevented.

[0263] In this invention, the above-mentioned CoFealpha alloy can be used as core material of for example, the thin film magnetic head. It is possible to manufacture the thin film magnetic head which was excellent in high recording density-ization by this, and was excellent also in corrosion resistance again.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Partial front view of the thin film magnetic head of the 1st operation gestalt of this invention,
[Drawing 2] Drawing of longitudinal section of drawing 1 ,
[Drawing 3] Partial front view of the thin film magnetic head of the 2nd operation gestalt of this invention,
[Drawing 4] Drawing of longitudinal section of drawing 3 ,
[Drawing 5] Drawing of longitudinal section of the thin film magnetic head of the 3rd operation gestalt of this invention,
[Drawing 6] Drawing of longitudinal section of the thin film magnetic head of the 4th operation gestalt of this invention,
[Drawing 7] Drawing of longitudinal section of the thin film magnetic head of the 5th operation gestalt of this invention,
[Drawing 8] 3 original drawings showing the relation between the composition ratio of a CoFeNi alloy and a NiFe alloy by which plating formation was carried out by the electroplating method using the pulse current, and saturation magnetic flux density,
[Drawing 9] 3 original drawings showing the relation between the composition ratio of a CoFeNi alloy and a NiFe alloy by which plating formation was carried out by the electroplating method using the pulse current, and coercive force Hc,
[Drawing 10] 3 original drawings showing the relation between the composition ratio of a CoFeNi alloy and a NiFe alloy by which plating formation was carried out by the electroplating method using the pulse current, and specific resistance,
[Drawing 11] 3 original drawings showing the relation between the composition ratio of a CoFeNi alloy and a NiFe alloy by which plating formation was carried out by the electroplating method using the pulse current, and membrane stress,
[Description of Notations]
11 Slider
10 Magnetoresistance-Effect Element
16 Lower Core Layer (Up Shield Layer)
18 30 Magnetic pole section
19, 32, 50 Lower magnetic pole layer
20 33 Gap layer
21 34 Up magnetic pole layer
22, 40, 46, 55 Up core layer
41 Magnetic-Gap Layer
47 High Bs Layer
48 Upper Layer

[Translation done.]